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SECED NEWSLETTER

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PROJECT DRAGON FLY

More than 50 people attended a joint SECED/WES meeting on the "Dynamics of Long Roof Spans" at the ICE on 28th February. Four speakers gave a variety of interesting presentations. **STEVEN LUKE** BSc, MSc, CEng, FICE, FIStructE, MHKIE (Ove Arup & Partners, Cardiff) covered the design of the new BA aircraft hangar at Cardiff airport.

The new British Airways three bay hangar at Cardiff airport is a highly complex aircraft maintenance facility providing a "state of the art" base for Boeing 747 aircraft. The Prince of Wales formally opened the £75 million facility on the 31st July 1993 and the aviation industry had its first look at the world's most efficient base of its kind.

Because of the hangar dimensions 242m x 90m x 33m high and the proximity to the main and secondary runways, windshear and turbulence were critical issues which required careful consideration. Wind Engineering was also an important aspect of the design of the building fabric and roof structure that included structural elements spanning up to 154m. This article discusses these matters and provides and outline of the maintenance operations which are undertaken in the facility. The site layout and the building plan and cross-section are shown in figures 1 to 3.

BUILDING CONCEPT

The project encompassed a double and single bay 22,000m^2 hangar with a 6,000m^2 mezzanine floor, 15,000m^2 support building, an aircraft run pen and a 35,000m^2 concrete apron. The hangar is also equipped in each bay with aircraft access docking, overhead aircraft lifting platforms and specialist services. The aircraft docking structure is designed to provide access to the nose, wings, fuselage and tail of the aircraft. Because the structure is suspended from the hangar roof and since the docking is a tight fit to the aircraft, control of building movement was critical.

CODES OF PRACTICE

At commencement of design the current standard for wind loads was CP3: chapter: V part 2: 1972 (1). This gave no guidance on the effect of the roof's eves details on windows or on complicated roof shapes. Data available from recent research work, particularly from the BRE, covering the basic wind speed in the United Kingdom and aerodynamic detailing, was considered to minimise wind loads (2 and 3).

Before undertaking the detailed engineering design a review of the wind aspects was undertaken with Mr Tom Lawson of Bristol University and Arup Wind Engineering group to consider the operational issues, environmental design and wind loading criteria.

At the time the design was undertaken the new British Standard for windloading (4) was in its ninth draft and because CP3 did not provide comprehensive, pressure coefficient guidance for large buildings a comparison of both codes was undertaken.

It was decided to adopt the worst case from the study to allow rapid design and ensure the current code requirements were satisfied.

OPERATIONAL ISSUES

Two wind engineering issues affecting the building concept were the wakes and the vortices which spring from the front corner of the roof when the wind is at an angle to the face of the building. In both instances the hangar was considered to be located in the most favourable position relative to the orientation of the runways.

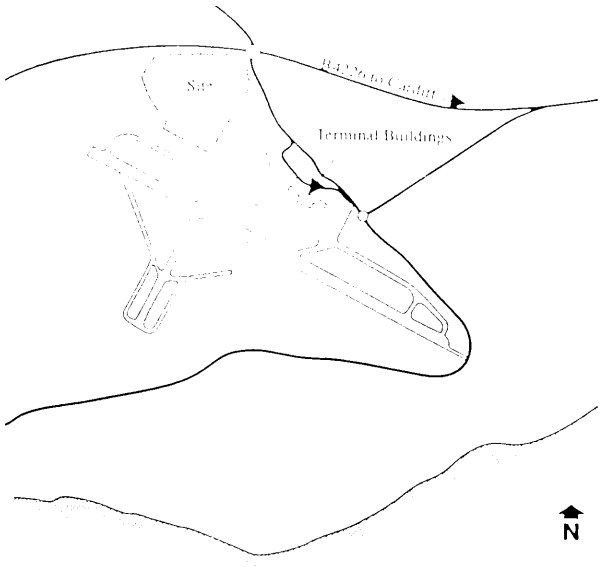

Fig 1- Site Location

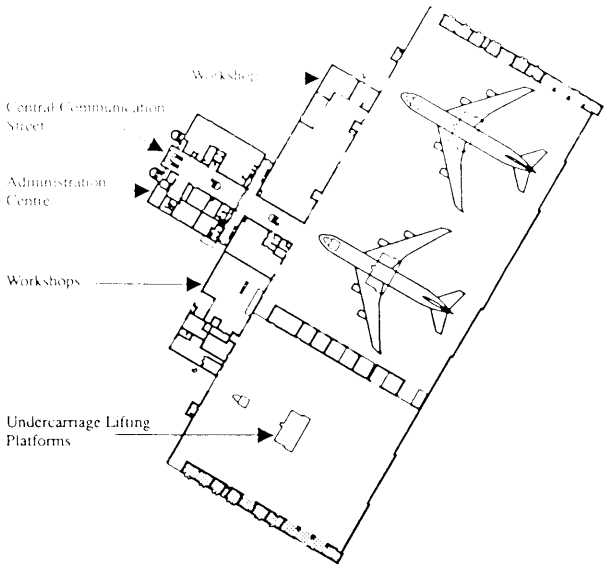

Fig 2- Hangar Plan

Major wakes produced by the broader front will be created by wind from the North or West (prevailing) and will blow over the end of the minor runway. The distance of the further edge of the runway will be around the attachment point and will suffer from reversal of wind direction, see figure 4. Since aircraft will not be airborne at the end of the runway these effects were not considered significant.

The minor wake (narrow aspect of the building) will blow over the main runway in East or North winds which are weak and infrequent. The tall part of the building is narrow so there should be no reversal of wind speeds (which will appear as cross winds) and the levels of turbulence will be small.

Vortices will spring from the upward corner of the roof of the building when the wind is directed onto the corner and take the form of a pair of contra-rotating vortices of rotational direction such as to induce downward winds between the vortices. They leave the building at a height of just greater than that of the building and drift slowly towards the ground being broken down by turbulence.

The vortices which pass over the short runway were considered not to pose a problem since the aircraft should be underneath their effect, if not on the ground where they pass. On the main runway the vortices may pass across the aircraft flight path if they have not already been broken up by turbulence. Also, because of the aircraft type and potential size this issue was also not considered to be significant. The alignment of the potential critical vortices is shown in figure 5. Following completion of the project these conclusions have been found to be correct.

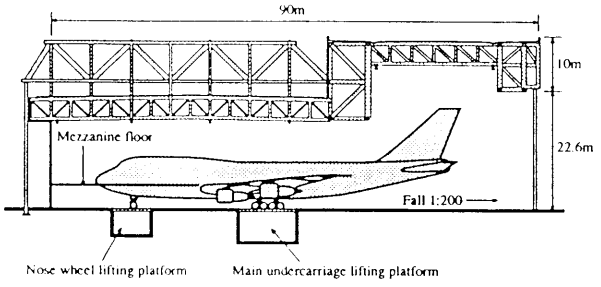

Fig 3- Hangar Cross Section

ENVIRONMENTAL ISSUES

Since the hangar shape is dictated principally by its function there is little flexibility in determining the shape. Nevertheless, the local climate outside the main personnel entrances and loading areas were given careful consideration in their positioning and design. In some instances entrances incorporated small canopies to provide shelter. Also, the workshops and offices were separated from the hangar except for local access at the rear where connecting doors are only open when people or goods are being moved from one area to the other. These openings did not connect with any other opening on a different face.

DOMINANT OPENINGS

The roof and walls were designed to withstand the maximum pressure difference across the construction. The value of the internal pressure was related to the size and position of the openings and it was predicted that the greatest pressure difference occurred with the wind blowing into the large opening of the aircraft doors, with all of them open. However, the design checked all combinations of open areas to determine the effect on high wind pressures. This involved a considerable number of load cases taking into account the variable wind speeds and combination of hangar door and access door being open. No guidance on size reduction factors was available to apply to the potential dominant openings but information on this matter is now available in BS6399.

WINDLOADING

CP3: chapter V gives the basic wind speed for Cardiff as 45m/s (this is equivalent to 162km/hr or 101mph). For a cladding element at a height of 35m above the ground (the maximum height of facility) the design wind speed is 49.7m/s with a corresponding dynamic wind pressure of 1.52kPa. When considering the

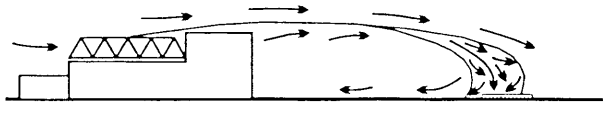

Fig 4- Wind Flow Turbulence

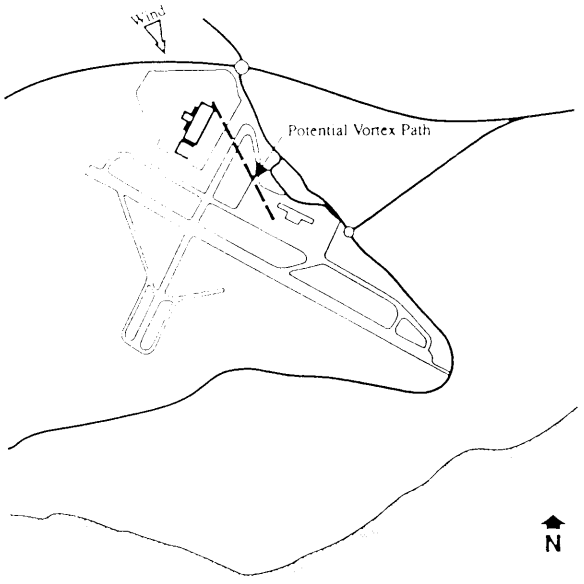

Fig 5- Potential Vortex Shedding

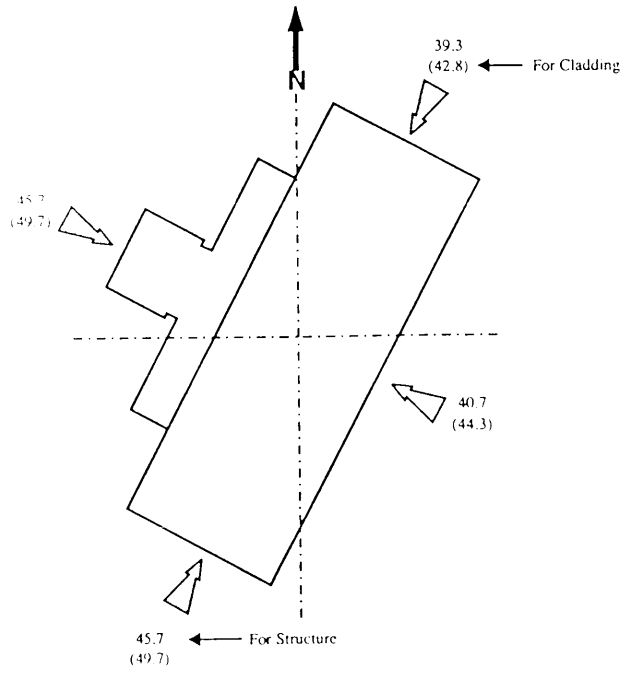

Fig 6- Design Wind Speed

building structure as a whole, the code allows for a reduced wind gust intensity and the appropriate design windspeed reduces to 45.7m/s with a corresponding wind pressure of 1.28kPa.

Since amendments to CP3: Chapter V permit the use of different wind speeds in different directions this refinement was adopted to benefit the hangar design because the doors face East, and South East but the prevailing winds come from the sector West, North West to South, South West. Therefore, the prevailing winds do not blow directly onto the hangar doors. The design wind speeds and the dynamic wind pressures at a height of 35m were computed at 30° intervals and the greatest values for each sector were used in the design. This set of results is illustrated in Figure 6.

The figures in brackets refer to cladding design data and by way of comparison the maximum design wind speed is reduced by 8% and the corresponding pressure by 19%.

The study also considered the effect of dominant openings and found that the maximum pressures formed are only slightly less than the pressures experienced due to the hangar doors remaining open. All possible conditions were taken into account in the structural and fabric design.

BUILDING STRUCTURE

Lateral wind loads would induce 20mm of lateral movement at the gable walls and approximately 70mm at the internal support with the wind blowing normal to the hangar doors. This movement was taken into account in the detailing of the building fabric but also in the positioning and final design of the suspended access docking to allow positioning tight to the aircraft skin.

The resultant roof pressures in some areas exceeded the minimal dead load and the structure was designed to resist resultant uplift action, but in general the average dead loading exceeded the wind pressures. In addition, because the deflection of the hangar roof was limited by the aircraft maintenance operations to 150mm under dead loading and 150mm due to imposed live loads. The roof structure provided a stiff construction with a low frequency which avoided dynamic vibration issues.

A detailed review of the building structure is covered in a paper by Luke (5).

FURTHER ISSUES

To the south of the hangar a ground run pen has been positioned with side and back walls of 10m height, and is used for engine testing. This structure was positioned sufficiently far from the south gable wall of the hangar that it would not have an effect upon the wind patterns.

At a later date an additional hangar may be built immediately to the north east of this hangar which should have no effect on the flow of wind over the runways. The gap between the proposed and the additional building could influence the cladding design loads and the spacing will be selected to minimise the increase.

CONCLUSIONS

The hangar is a significant building and the study of wind was an important consideration in the design of the fabric/structure and on the operation of the airport.

Although large buildings can benefit from local design treatment to soften the effects at the edges, this was not possible to accommodate within the hangar design but the directional wind study combined with a review of the dominant opening effects were key aspects to optimise the design.

Following the wind engineering desk study it was decided that there would be no useful purpose in conducting a wind tunnel investigation for the form of structure proposed.

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3. N J Cook The designers Guide to Building Structures: Part 2 static structures.
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JAPAN - UK SEISMIC RISK FORUM

WORKSHOP ON IMPLICATIONS OF RECENT EARTHQUAKES ON SEISMIC RISK
IMPERIAL COLLEGE, LONDON, 2-4 APRIL 1996

The First Workshop of the Japan-UK Seismic Risk Forum, under the title of *Implications of Recent Earthquakes on Seismic Risk,* took place at Imperial College in London from 2-4 April 1996. The Workshop, which was organised by Professor Amr Elnashai - who is the UK Regional Co-ordinator of the Forum - was attended by 89 participants from Japan, the UK and Europe, representing academic institutions and engineering practice. The Workshop took place with the sponsorship of the British Council (Japan), Sir Alexander Gibb and Partners, EQE International, Rendel Palmer and Tritton, the British Geological Survey, the Building Research Establishment and Imperial College.

The Japan-UK Seismic Risk Forum has been formed as a collaborative endeavour between seismologists and earthquake engineers in both countries. The Honorary Presidents of the Forum are Professor T. Kimura , President of the Tokyo Institute of Technology, and Professor P.J. Dowling FRS, Vice-Chancellor and Chief Executive of the University of Surrey.

JAPANESE DELEGATION

The delegation from Japan was headed by Professor Koichi Takanashi from the Institute of Industrial Science (IIS) of the University of Tokyo, who is the Japanese Regional Co-ordinator of the Forum. The other members of the Japanese delegation were Professors Y. Nakano and F. Yamazaki , also from IIS, Professors K. Kawashima, J. Koseki, S. Midorikawa and A. Wada from Tokyo Institute of Technology, and Professor K. Takiguchi from the University of Chiba.

EUROPEAN OBSERVERS

The Workshop was also attended by a number of distinguished European observers: Professor A. Ansal (Istanbul Technical University), Professor G.M. Calvi (University of Pavia), Professor P. Fajfar (University of Lubljana), Professor G.G. Penelis (University of Thessaloniki) and Professor T.P. Tassios (National Technical University, Athens).

The Workshop consisted of five sessions, each addressing one of the research topics which are covered by the Working Groups of the Forum: Seismic Hazard and Engineering Seismology; Foundations and Geotechnical Structures; Performance of Buildings and Bridges; Assessment, Repair and Retrofitting; and Risk Assessment, Education and Awareness. A total of 34 excellent presentations were made on subjects extending over the full range of earthquake risk assessment and mitigation. Of particular interest were the presentations delivered by the Japanese delegates on their research into the effects of the Hyogo-ken Nanbu earthquake of January 1995. Several of the UK delegates had also visited Kobe in the aftermath of this earthquake in order to carry out field investigations and indeed this was the origin of the Japan-UK Forum initiative. The quality of the presentations and the interest in the research presented were testified to by the lively discussion generated in all of the sessions and also by the fact that all of the sessions were well attended, despite their long duration.

SEISMIC HAZARD

The first session of the Workshop was on the theme of Seismic Hazard and Engineering Seismology, chaired by Dr. Julian Bommer (Imperial College). The Japan Co-ordinator on this topic, Professor Saburoh Midorikawa opened the meeting with a presentation on strong ground-motion in the 1995 Hyogo-ken Nanbu earthquake. A particularly interesting feature of his research was the influence of the deep geological structure (the 1 km offset of the basement across the Rokko fault) in causing focusing of seismic energy that resulted in the very high intensities observed in parts of Kobe. The European observer, Professor Atila Ansal then discussed seismic risk analysis from an engineering perspective, which raised several issues regarding the uncertainties in the assessment, particularly in terms of characterising the site response. This theme was also covered by Professor Nicholas Ambraseys in his presentation on the development of predictions of peak acceleration and spectral ordinates in Europe. Prof. Ambraseys also presented current research on the prediction of permanent displacements induced by earthquakes in slopes and on the evaluation of long-term seismicity in the Eastern Mediterranean, the Middle East and Central America. Dr. Paul Burton (University of East Anglia) presented his work in using microearthquake recordings from networks in Pavliani and Patras in Greece to assess seismotectonics, earthquake rupture properties and the potential for major earthquakes. Dr. Roger Musson (British Geological Survey) presented recent work on seismic hazard mapping for the UK, for both offshore and land areas, indicating the uncertainties that still remain, particularly with regard to the attenuation of peak acceleration in the UK. Dr. Bryan Skipp (Technology Transfer Associates) offered a thought-provoking discussion on the type and extent of the information required for site specific seismic hazard assessments, in the light of three decades experience of seismic hazard assessments throughout the world. The final presentation was given by Dr. Gordon Woo (EQE International) who summarised the development of seismic hazard evaluation procedures since the introduction of the Cornell method, including the shortcomings and the widespread mis-use of some the methods, particularly how the construction of Euclidian zone boundaries is liable to give a distorted image of the fractal pattern of

seismicity. As an alternative, Dr. Woo proposed the use of statistical methods based on kernel estimation of activity rate density to obtain seismic zonation.

GEOTECHNICS

The second session addressed the themes of Foundations and Geotechnical Structures and was chaired by Professor David Muir Wood (University of Bristol/Babtie Group). The session was opened by Professor Junichi Koseki who presented the behaviour of different types of retaining walls for railway embankments during the Hyogo-ken Nanbu earthquake, including the different types and levels of damage suffered. Zygmunt Lubkowski presented seismic analyses carried out on recent projects by Ove Arup & Partners, which included major soil-structure interaction studies for a warehouse in Japan and a river bridge in southern Europe. The presentation also covered site investigation to determine dynamic soil properties and the calculation of dynamic site response, in which comparisons were made between layer response analysis and site-dependent attenuation equations for response spectral ordinates, which provoked some lively debate. Even more animated discussion was generated by Dr. Scott Steadman (Sir Alexander Gibb & Partners), who discussed the degradation and failure of geotechnical structures, with particular reference to the performance of quay walls in the port of Kobe during the Hyogo-ken Nanbu earthquake. Dr. Steadman argued for a revision of the factor of safety approach to the design of geotechnical structures since the onset of damage due to earthquake loading is rarely an indication of failure and hence the factor of safety is not a useful concept. The experience in Kobe highlights the need for design performance criteria based on displacements and a definition of failure in terms of the nature of final collapse. Dr. Andrew Chan (University of Birmingham) presented studies originated in the University of Glasgow on numerical analysis in soil dynamics, with particular emphasis on the use of fully coupled Biot equations to represent the two phases (solids and pore water) and the development of constitutive models for application in finite element analyses. The predictions using these models were compared very favourably with results from centrifuge tests. Recent developments in centrifuge testing was the topic of the presentation by Gopal Madabhushi (University of Edinburgh), who described the limitations of the 'bumpy road' earthquake actuator that had been used at Cambridge, since the frequency and duration of the simulated earthquake motion are fixed at any one 'g' level. The Stored Angular Momentum (SAM) based actuator developed at Cambridge University now permits centrifuge tests with earthquake loading in which the frequency, duration and intensity of the shaking may all be varied. Dr. Kenichi Soga presented other aspects of research into the dynamic cyclic behaviour of soils being carried out at the University of Cambridge, which in particular is addressing the fact that although the shear modulus-strain relationships from field observations (such as the 3-D array on Port Island in Kobe) are similar to those obtained in laboratory tests, the damping behaviour is less well understood. One focus of the research is the influence of using different pore fluids on the soil element behaviour in centrifuge testing. Mr. P. Woodward presented current research work in the field of geotechnical earthquake engineering at Heriot-Watt University in Edinburgh, including the implementation of advanced constitutive models for simulating the cyclic and dynamic behaviour of soils and experimental investigation of soil and soil-composites, using additive materials such as rubber, under cyclic loading. Recent work on the seismic behaviour of bridge foundations using both base isolation and hydraulic damping systems was also presented.

STRUCTURES

The topic of the first session on Wednesday afternoon was the Performance of Structures; the two sub-sessions were on Buildings, chaired by Professor David Key (CEP Research), and on Bridges, chaired by Professor Elnashai. The entire session lasted three and a half hours, without an intermediate coffee-break, which probably constitutes a world record! Nevertheless, it was well-attended from the beginning to the end, which is a clear indication of the quality of all the presentations.

The sub-session on Building Performance was opened with two invited presentations from Japan; Professor Takanashi discussed a number of interesting case-studies involving steel buildings that suffered brittle fracture of members and/or connections during the Hyogo-ken Nanbu earthquake, while Professor Wada introduced the concept of "Damage tolerant structures", wherein earthquake damage is concentrated in certain members ("seismic elements"), and the rest of the structure remains essentially damage-free. The European observer Professor Peter Fajfar reviewed the new trends in Europe with regard to the seismic design and assessment of buildings, and focused on a simplified nonlinear design method (the "N2-method") developed at the University of Ljubljana for structures responding essentially in their fundamental mode.

Four interesting presentations from UK participants were included in the first sub-session: Edmund Booth (Consultant) discussed the main results from a major project involving a comparative study of current seismic design regulations, funded by the UK Nuclear Industry; Dr Adam Crewe summarised recent research activities at the University of Bristol on various aspects (experimental, as well as analytical) of earthquake engineering; Dr Andreas Kappos (Imperial College) presented a new capacity design methodology for R/C structures, relying on the use of currently available advanced analytical tools; Dr Adrian Chandler reviewed recent research on torsional response of buildings at University College London, and also referred to the current activities of the newly established EAEE Task Group on Seismic Performance of Irregular and Complex Structures. The sub-session was concluded with a presentation from Professor M. Sobaih (University of Cairo) who reviewed current research activities and seismic design procedures in Egypt, as well as damage from the 22 November 1995 (M_S = 7.2) earthquake in Nuweiba.

The sub-session on Bridge Performance was opened by Professor Kawashima, who made an impressive presentation of seismic damage data in Japanese bridges, covering the entire period from the

Great Kanto Earthquake of 1923 to the recent (1995) Kobe Earthquake.

The European observer Professor Calvi discussed current trends in the design of isolation systems for bridges in Europe and worldwide, focusing on the new concept of displacement-based seismic design.

Two interesting presentations from UK participants concluded the second sub-session: Mr. A. Hoy (EQE) discussed the problems involved in the assessment and the design of the strengthening scheme for the Carquinez bridges in the San Francisco (Bay) Area; the dilemmas and challenges for the structural engineer involved in bridge design were addressed by Mr Joe Barr (Rendel Palmer and Tritton), who focused on the rapidly advancing isolation technology, pointing out that experience so far is scarce, but mostly encouraging.

The 32 hour session ended with a presentation from Professor Haig Gulvanessian, who gave an overview of current research activities and planning of future programmes at the Building Research Establishment, with special reference to the Cardington large building test facility.

ASSESSMENT & REPAIR

The session on Assessment, Repair, and Retrofit, chaired by Dr A. Kappos, included a total of seven presentations. Professor Nakano discussed current procedures in Japan for quick post-earthquake inspection of damaged buildings, with particular reference to the recent experience from the Hyogo-ken Nanbu earthquake. The European observer Professor Tassios gave an overview of the provisions of Eurocode 8 (Part 1-4), which deals with seismic assessment and repair of structures, and focused on the problems encountered in developing reliable models for calculating the resistance of damaged members before and after repair or strengthening.

A total of five presentations from UK participants concluded the session on Assessment and Retrofit: Dr. H.R. Ahmadi (Malaysian Rubber Producers' Research Association) presented an interesting case-study involving the retrofit of an existing five-storey masonry building in Spitak (Armenia) using base-isolation; Dr. J. Littler (BRE) described the BRE capability for dynamic (in-situ) testing, as well as the new large building test facility; Mr. T. Piepenbrock (Ove Arup) discussed the problems encountered in the retrofit of the US Court of Appeals Building in San Francisco, using friction pendulum seismic isolators, and showed an interesting video from the shaking table study (at EERC, Berkeley) of a reduced model of the structure; Dr K. Pilakoutas (University of Sheffield) presented results from recent experimental studies on the behaviour of RC members strengthened using external lateral prestressing ("strapping" technique); finally, Mr. D.G. Smith (Scott Wilson Kirkpatrick) presented a case-study of seismic assessment, involving the Alcazar Hotel in Aqaba (Jordan), which is a vernacular R/C structure, and suffered severe damage in some members during the 1995 earthquake in the area.

It is worth pointing out that discussion followed each presentation (rather than taking place at the end of each session, as foreseen in the initial programme), and this proved to be a good idea, as numerous questions and remarks were made, indicating the great interest the participants took in the presentations.

RISK MANAGEMENT

The last session of the Workshop took place in the morning of Thursday, and the topic addressed was Risk Management, Education, and Awareness; the session was chaired by Dr Robin Spence (Martin Centre) and included a total of seven presentations. At the beginning of the session the chairman briefly reviewed the UK activities in earthquake risk management and awareness, making also reference to vulnerability and casualties assessment studies at Cambridge University and elsewhere, and on field missions to earthquake sites.

Two presentations were made by invited speakers from Japan: Professor Yamazaki discussed the development of an interesting early-warning system for large scale gas networks, triggered on the basis of a real-time earthquake damage estimation system, predicting tsunamis, structural damage, and casualties; Prof. Takiguchi presented some proposals for the mitigation of natural disasters in urban areas, and also discussed some case-studies of damaged R/C buildings in Kobe.

The European observer Professor Penelis presented an overview of Seismic Risk Management, emphasising the feasibility of each of the two main approaches, the rigorous one involving advanced structural and economic (cost-benefit) analyses, and the (semi)-empirical one followed by most national agencies worldwide, involving emergency plans and various public awareness programmes.

The session was concluded by three presentations from UK participants: Mr. Antonis Pomonis (Cambridge Architectural Research) described two damage surveys carried out in the Kobe area after the recent earthquake, to establish the seismic vulnerability of Japanese buildings and the associated human casualty rates; Dr. D. D'Ayala (University of Bath) presented the results of a recent study involving a district with historic buildings in Lisbon, using a limit-state approach for assessing the seismic vulnerability (including some analysis for idealised failure mechanisms); Dr. Ian Davis (Oxford Centre for Disaster Studies) made an interesting presentation on risk assessment from the planner's view (rather than from the engineer's), discussing the obstacles to developing risk assessment procedures, the sequential stages of risk assessment, and situations where this procedure is neglected or is still in its infancy.

The Workshop provided an ideal opportunity for UK earthquake engineers to meet colleagues from Japan and to learn about the extensive research work being done in many institutions there. At the same time, the Workshop enabled the Japanese delegation to see at first hand that although the UK is a country with low earthquake activity, it has a very high level of earthquake research activity. A number of important resolutions and agreements for further co-operation have come out of this first meeting, and future collaborative activities are currently under consideration.

Chairman's Annual Report
May 1995 to April 1996

1995/96 has been another extremely successful year for SECED. The year was dominated by our two premier events, the Mallet-Milne biennial lecture, and the triennial Conference.

TECHNICAL PROGRAMME

The Fifth Mallet-Milne lecture in May last year drew a capacity audience to Professor Bruce Bolt's lecture "From Earthquake Acceleration to Seismic Displacement". The event reflected strongly the spirit of Mallet and Milne by bringing together geologists, engineering seismologists and earthquake engineers to hear Bolt's views about the importance of "ground fling" and other factors surrounding the engineering definition of seismic hazard. The reputation of the lecture series has now become firmly established and the lecture publications have built into a significant body of work containing much insight and experience from some of the most distinguished figures in the field from around the world today. This year's publication, available again through John Wiley & Son, has already been cited widely as a clear and concise source of information about the physical nature of earthquake ground motion.

In October our conference on "European Seismic Design Practice - Research and Application" attracted many prominent figures form the European earthquake engineering science and made a significant contribution towards enhancing SECED's profile within Europe. The conference dealt with specific topics of timely interest through two days of clearly focused presentations. The thanks for organising the conference go to Professor Amr Elnashai of Imperial College London who, along with his organising committee, devoted a great deal of energy and dedication to make this a truly first class event. The selection of a European theme for the Conference reaffirms SECED's commitment to be at the heart of European affairs, and indeed to take a leading role in many of the initiatives being developed across Europe.

Plans are beginning to materialise for the organisation of the next conference in 1998. This will be the last conference before the next millennium so please let the Committee know if you have any suggestions or comments for the format of this key event.

The remainder of our technical programme this session also proved to be extremely rich and varied. The 5 evening meetings and 3 full day fee paying events covered a wide range of topics in the fields of earthquake engineering, blast and general civil engineering dynamics. Attendance at the meetings has been extremely encouraging, generally between 60 to 100 at each meeting, with often more than half the audience being non-SECED members. The high level of interest clearly reflects the relevance and quality our programme has become known to offer.

Earthquake engineering continued to be the main focus of the programme with 5 of the 8 meetings arranged on this topic. The meetings on the whole centred on the examination of new developments in a number of areas including particularly the seismic design of bridges and steel building structures following findings from the Kobe and Northridge earthquakes. The full day meeting on steel structures, which was sponsored jointly with the Institution of Structural Engineers, was hugely successful and indeed oversubscribed. The meeting presented very much a state-of-the-art statement by our distinguished overseas and UK speakers and the authors have very kindly agreed to provide a written version for publication, based on their presentations. Other seismic topics addressed during the year included a one day seminar on dynamic soil-structure interaction and, in the meeting this evening, new controversies in engineering seismology. The seismic soil-structure interaction seminar was organised jointly with the Association Francaise du Genie Parasismique (AFPS) and proved to be not only a technical success but also a valuable social occasion which should help further advance close working relationships with our European colleagues. Additionally, our forthcoming meeting in May, organised jointly with the British Nuclear Engineering Society (BNES), will address important issues surrounding the seismic qualification of existing nuclear plant.

Non-earthquake dynamics were covered in three evening meetings which dealt with subjects as diverse as the effect of blast loading on building cladding systems; dynamics of long span roofs (organised jointly with the Wind Engineering Society); and the impact of railway noise and vibration on the environment. It is of note that these meetings, which all addressed timely topics, attracted a similar level of interest as the earthquake engineering meetings.

The issue of charges which have been applied to a number of our events this year has been of some concern to the Committee. To some extent we suffered from our own success in that an unexpected number of meetings developed into full day events thereby attracting catering charges and the like. The Committee are conscious that SECED's prime task is to promote free discussion on earthquake and civil engineering dynamics and is taking steps that the balance of charge to no-charge events is redressed.

NEWSLETTER

The Newsletter, through the guidance and editorship of Tony Blakeborough has resumed its role as a key contributor to the output of our Society. The membership survey conducted last year confirmed the importance of the Newsletter as an essential means of communication, which is highly regarded by the majority of members. The Committee clearly recognise that the strength of the Newsletter rests mainly with the editor and contributing authors and is committed to finding ways to ease the burden of production and improve upon its quality and regularity of distribution. The Newsletter will soon

be available on the SECED World Wide Web pages (see below) and hence readily accessible to a far greater audience than in the past, making it even more important that contributions from the UK earthquake and civil engineering community are fully represented at an appropriate level. The Newsletter thus has a key role to play in establishing and developing this kind of international contact, and has a significant contribution to make outside the confines of our profession. Earthquake engineering after all is a global concern which arouses great interest across many other disciplines as well as in the eyes of the pubic at large. The Newsletter has the ability to chronicle and present our work in an exciting, interesting and informative way, which can stimulate debate and reveal the value of our profession to a extremely wise audience.

MEMBERSHIP

The Membership Sub-Committee have scrutinised the results of last years membership survey and have made recommendations to the Committee for future improvement in the level of service provided by the Society. Whilst the survey provides a large measure of the importance the membership attribute to the Newsletter, it also demonstrates that our technical activities are highly regarded and greatly appreciated. The overall message appears to be that the Society is satisfying a real need through the organisation of our conferences, lectures and publications, although clearly there is much more that can be achieved.

A body of information about SECED will soon be available through world wide web pages on the Internet. Kypros Pilakoutas at the University of Sheffield is leading the way on this initiative and is co-ordinating our entries. Suggestions from the membership are of course always welcome.

SECED also continues to maintain and develop access to information about leading organisations and individuals in our field of interest through the publication of Directories. The SECED Directory of Practitioners disseminates information on UK companies, research institutions, laboratories and suppliers involved in the field of earthquake and civil engineering dynamics (the 5th edition was distributed widely at our conference last October), and the soon to be published SECED Membership Directory will disseminate information about individual SECED members. (For those who have not yet returned their Membership Directory entry forms please do so soon - publication of the Directory is imminent). Together these Directories represent a UK skills register in the field earthquake and civil engineering dynamics. Both Directories will shortly be entered on the world wide web and thus made freely available throughout the world.

FINANCE

The financial position of the Society strengthened considerably during the year principally due to the overwhelming success of the Conference, and also due to profits generated by the production of the Directory of Practitioners. The surplus which has now accumulated puts SECED on a sound financial footing which will provide a secure basis on which future activities may be confidently taken forward. The funds will allow us to underwrite risk associated with the organisation of future conferences as well as fund a more diverse set of activities.

For instance the Committee has recently endorsed the creation of an "Enabling Fund", generated mainly from profits derived from the IDNDR Conference, to provide a source of cash flow support to young engineers seeking experience or training in the field through post-earthquake investigations (anyone wanting details should contact the Committee).

Additionally, we have under review provision of extra funding for the Newsletter to strengthen its production values and to provide much needed support to the editor.

We are also examining the options available to support the creation of a completely new series of occasional SECED technical publications based upon some of the key state-of-the-art meetings held from time to time as part of our annual technical programme. In all, the security of funding will provide an opportunity to achieve "more for less", thereby providing a higher level of service to members in future.

A detailed financial report is given separately by our Treasurer, Dr Chris Browitt. The unstinting efforts by Chris in keeping our finances under taut control, ably supported by Mary McBride, ICE's chief accountant, is gratefully acknowledged.

COMMITTEE

The Committee remained largely unchanged following the re-election last year of Chris Browitt, David Mallard and Peter Merriman although Julian Bommer was welcomed as an elected member for the first time. It must be emphasised that SECED's effectiveness stems largely from enthusiastic and dedicated voluntary contributions from individual members and in today's climate the value of this commitment should not be underestimated and needs to be widely acknowledged. New blood is always welcome and for those who would like to help with Society affairs in the future please do not hesitate to contact the Committee.

It is not often that we are able to recognise the special contribution only a few can make towards the well being of the Society. It is therefore with tremendous pleasure that I am able to announce on the occasion of the year's AGM the award of honorary life membership to Dr David Key. David has served the Society in many capacities consistently over a long period, most notably as Chairman in 1984-86. He has made a significant contribution to the development of the earthquake engineering community not only here in the UK but also in the Caribbean, and he continues to participate strongly in many of our activities.

FUTURE FRAMEWORK

The ICE's Future Framework Working Party initiative on the future direction of the Institution of Civil Engineers has provided an opportunity to review SECED's learned society contribution to Institution affairs. In this capacity SECED acts as a specialist sub-group which provides a vital link with other societies, institutions and other engineering and scientific disciplines with an interest in our subject. Many of our members are non-ICE members. Also because of the international nature of earthquake

engineering we have forged many links at the European and international levels, leading to recognition of SECED as the UK centre of expertise in the field of earthquake and civil engineering dynamics. The enthusiasm and vigour with which our members approach societies, will always be significant.

As for the future, SECED should continue its prime function of promoting co-operation in the advancement of knowledge through the free dissemination of information on earthquake and civil engineering dynamics, under the umbrella of our sponsoring Institutions.

CONCLUSION

Much has been done during the year through the success of our conference and Mallet Milne lecture to build upon the reputation SECED has established both in the UK and overseas. There is a great deal more to be achieved and we can look forward with confidence that SECED will continue to develop its pivotal role within the earthquake and civil engineering dynamics community.

This report marks the end of my term as Chairman. It has been a real pleasure and privilege to serve the Committee as Chairman over the last two years. The role has been a great challenge for me, made considerably harder by changed circumstances in my working environment, but the results have been immensely rewarding.

I would like to thank the other members of the Committee for their support during my term in office, and, as this important post is passed to our new chairman, John Maguire, I know that the leadership of the Society is left in very capable hands.

Nigel Hinings
Chairman

20 April 1996

The Fifth Mallet-Milne Lecture

From Earthquake Acceleration to Seismic Displacement

Robin Adams reviews the published version of Bruce Bolt's lecture

From Earthquake Acceleration to Seismic Displacement: The Fifth Mallet-Milne Lecture by Bruce A. Bolt.

Society for Earthquake and Civil Engineering Dynamics (SECED), London :John Wiley & Sons, Chichester. ISBN: 0 471 96133 7 (50pp).

This is a pleasantly presented volume, starting with an introduction from the SECED Chairman, and a brief biographical sketch of the lecturer, who is known and respected throughout the seismological and earthquake engineering communities. The text is well illustrated with clear diagrams and almost entirely devoid of printing errors.

In his Introduction, Professor Bolt states that the aim of the paper is to provide a critique of present common methodologies for assessing the input ground motion necessary for the design of earthquake-resistant structures. This problem has long frustrated those trying to find simple, logical and repeatable relations between the size and position of an earthquake and the detailed distribution of its effects, despite the quoted view of Mallet that "..... this apparent confusion is but superficial."

Professor Bolt successfully bridges the gap that often exists between seismologists and engineers. An applied mathematician by training, he appreciates the engineer's desire to categorise and quantify, while understanding the difficulties of the field seismologist in reporting earthquake propagation and effects. He points out differences in terminology, but also appreciates the common features of the two disciplines.

Basic concepts have developed in the last few decades to improve the characterisation of seismic ground motion. These include the ability in modelling earthquake motion to take account of the type of source mechanism, and the allowance for directivity in a wave propagation pattern. But the most significant change is the realisation that the concept of peak ground acceleration, independent of frequency content or duration, that dominated the subject for so long, is not the best descriptor of the likely effect of vibration on a structure. In particular, the importance of displacement or "fling" near a fault was pointed out by Professor Bolt himself more than 20 years ago.

There has also been growing realisation of the importance of non-linear effects, helped by the increasing improvement in strong-motion recording networks. For instance, at soft soil sites about 90km from the Loma Prieta earthquake of 1989, the amplification of ground motion of the main shock was about 4 compared with sites on rock, but from 10 to 25 for weaker aftershocks. It is thus inadvisable to extrapolate from weak motions to predict strong ground motions in rapidly-varying complex media.

In summarising the present position Professor Bolt gives a table of extreme horizontal wave amplitudes for a selection of recent large earthquakes, from San Fernando (1971) to Hyogo-ken (Kobe) (1995), but warns that these are not typical. In particular, some sites, such as that at Tarzana near the 1994 Northridge earthquake have topographic peculiarities that could explain their high readings. He also points out that direct recordings of ground velocity and even displacement are now becoming available, so it is no longer necessary to rely on dubious integration of acceleration records. It remains essential, however, to develop analysis of the way damage can be correlated with records of ground motion.

In a final section ideas are given for improvements, building on the enhanced ability to predict strong ground motions. In particular there is a need for ground motion recording near structures damaged in an earthquake, as is being implemented in California with the installation of "Reference Accelerometer Stations"

near all significant groupings of critical structures. There is also need to investigate the correlation among the different orthogonal components of motion to reveal, for instance, any rotational motion, and to check the effect of vertical motion. There is still no proper accounting for the observed incoherency in the strong motion patterns of many earthquakes, despite efforts such as those of Professor Bolt in interpreting records from closely spaced recording networks such as the SMART array in Taiwan.

The book is a worthy addition to this prestigious series. Professor Bolt is uniquely qualified to give this overview of the development of the blending of seismology and earthquake engineering, its past history, its present state and needs for the future. As Nigel Hinings, states in the Foreword, the lecture "will become essential reading for engineering seismologists and earthquake engineers alike, since it highlights areas where closer integration of these two disciplines is key to the development of improved specifications for earthquake hazard in the design process".

SECED QUESTIONNAIRE 1995

John Inkester, Chairman of the Membership Sub-committee, reviews the results

The SECED committee sent out a questionnaire in February 1995 to its members to discover their views on the services provided by SECED. The bottle of champagne (raffled to encourage replies) was won by Dr.W.H.Craig from Manchester University.

Forty seven completed questionnaires (about 15% of the membership) were returned. Replies were received from all classes of member (individual, student, corporate, retired and overseas). Although the profile of returns was not entirely consistent with the make-up of the SECED membership there was no obvious bias.

SERVICES
The first question asked members to indicate the service which they find most valuable from SECED. The overwhelming response was that the newsletter is the most popular item followed by the Mallet-Milne lecture, evening seminars, half-day meetings, full conference, mailshots and Practitioners' Directory.

AREAS OF INTEREST
The second question tried to ascertain the technical areas and subjects members would most like to hear discussed.

It was very clear that earthquake topics were the most popular, the main topics of interest being seismic hazard, earthquake analysis and design. Vibration, wind, blast and impact fell some way behind. Several subjects for discussion were suggested and will be considered for future meetings.

MEETINGS
Attendance at meetings was reviewed in question 3. The 'average' respondent attended 2.5 SECED events in a year. Not surprisingly, for those who work in London the attendance rate increased to 3.5, and dropped to 2 for those employed outside (30% of questionnaires were completed by members employed in London). The highest attendance rate was 8 per year by a member living and working in the London area. However, distance does not necessarily appear to be an obstacle, a member living in Edinburgh achieved 7 attendances per year and one from Athens 2.

The evening seminar is the most widely attended SECED event with 72% of respondents having been present at at least one meeting a year.

NEWSLETTER
Question 4 reviewed the content of the newsletter. In general the respondents felt that the apportionment between news, features, the diary and the frequency of production was about right.

There were many complimentary remarks made about the newsletter and it is highly regarded by members. The main criticisms were over its occasional late production.

MEMBERSHIP FEES
The individual and corporate membership fees were considered reasonable, with more than 80% of respondents saying that they were about right. Six former students are now full members.

Various suggestions were made for improving SECED. These included :-

- 25% of the respondents who were based outside London requested more regional meetings.
- Introductory lectures may help to widen membership and encourage new members and students.
- Increased co-operation with other learned societies.
- Use of Internet and electronic mail for communicating with members and other groups.
- Subject areas should be regularly reviewed to ensure the correct balance is maintained i.e. no over emphasis on a particular technical field.

Many of the above points have been addressed by the committee and implemented in the 95/96 programme. For example meetings have been held at Risley, Warrington and the conference on 'European Seismic Design Practice' took place in Chester. Imperial College are running an introductory short course on 'Practical Seismic Design' in collaboration with SECED. Meetings have been held with other learned societies e.g. BNES, AFPS. The Newsletter will soon be available on the SECED World Wide Web page.

The questionnaire was felt to be a worthwhile exercise in determining the views of the membership. But it need not stop there: if you feel strongly about a policy or, have ideas or suggestions, please write to the committee and make your views known.

31 January Meeting: Steel buildings

Seismic Design of Steel Buildings after Northridge and Kobe.

Ed Booth reports on the meeting jointly organised by SECED and the Institution of Structural Engineers

There was a capacity audience for this one day seminar, organised jointly by SECED and the Institution of Structural Engineers, which addressed the problems in steel buildings revealed by recent earthquakes in California and Japan. The seminar was chaired by Professor Michael Burdekin and addressed by distinguished speakers from USA, Japan and the UK.

CRACKED CONNECTIONS

Professor Michael Engelhardt (University of Austin, Texas) summarised the results of two years extensive research which followed the discovery after the 1994 Northridge earthquake of cracks in the beam to column connections of over 100 steel moment frame buildings.

The standard connection detail specified in the code and used in almost every steel frame building in California since the 1970's, has since been shown to be unsatisfactory, even with closely controlled welding under laboratory conditions.

A three pronged approach to improved design is now considered necessary - better welding methods and materials, improved design to reduce stresses at connections, and improved material properties in the structural members. Although much progress has been made, there is still some way to go before fully accepted and reliable connection details are established.

COMMON PROBLEMS

Professor Akira Wada (Tokyo Institute of Technology) cited fractures found in the beam to column joints of 40 buildings in Kobe, following the 1995 earthquake. The fractures were found in the heat affected zones of shop welds, as well as in site welded connections and failures were found in designs quite different from the Californian ones.

While approaches similar to the three pronged one described by Prof Engelhardt are accepted as valid in Japan, a new more radical direction is becoming (post Kobe) the norm for tall buildings.

This involves the rejection of ductile moment frames in favour of a primary gravity load bearing structure designed to remain elastic during a severe earthquake, with a parallel energy dissipating system; this has taken the form of yielding steel shear walls (a form of construction which performed well in the Kobe City Hall) and more radical options, including viscous sandwich panel dampers.

VERTICAL COMPONENTS

Professor Amr Elnashai (Imperial College, London) described research work designed to complement the US investigations. His work has addressed two areas: firstly, the effect of vertical accelerations on connection response and secondly the use of semi-rigid frames for seismic resistance.

Vertical accelerations in both Kobe and Northridge earthquakes were an unusually high proportion of horizontal motions. Analytical studies have suggested that vertical excitation of beams by vertical seismic motions contributed significantly to connection demand, particularly in long span beams, and may help to explain the connection failures.

In the second area of study, pseudo-dynamic tests on semi-rigid frames show that their seismic deflection response can be at least as low as for equivalent rigid frames, while releasing the moment demands at connections. This deserves consideration as design option which could alleviate the connection problem.

MATERIAL APPROACH

Simon Cardwell (Ove Arup & Partners, London) described his approach as a material scientist.

Fracture mechanics solutions, which are now well developed for static problems, can equally be applied to seismic loading. Given a stress state and maximum defect size, minimum acceptable material properties can be specified, particularly with respect to fracture toughness.

The more general implications of alternative design solutions can also be assessed from a fracture analysis standpoint; for example, the use of flange doubler plates, while superficially attractive in lowering stresses, may increase the tendency to fracture by increasing restraint.

PERFORMANCE REVIEW

David Smith (Scott Wilson Kirkpatrick & Partners, Basingstoke) provided a review of the seismic performance of steel buildings over the last 40 years. He gave a more detailed review, from his own surveys, of such buildings in Northridge and Kobe, with special attention to car park structures (where the absence of non-structural elements allows a clear view of structural response), column base plates and Japanese SRC (steel reinforced concrete) construction.

Proceedings of the seminar will be published jointly by the Institution of Structural Engineers and SECED. Details will be announced in due course.

NOTABLE EARTHQUAKES JANUARY - MARCH 1996

Reported by British Geological Survey

YEAR	DAY	MO	TIME UTC	LA	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
1996	01	JAN	08:05	0.72N	119.98E	33		6.2	7.7	MINAHASSA PENINSULA
				At least 8 people killed, one person missing and over 200 houses and buildings damaged in the Tolitoli area. A local tsunami contributed to damage in the epicentral area.						
1996	03	FEB	11:14	27.29N	100.34E	10		6.3	6.5	YUNNAN, CHINA
				At least 251 people killed, 4,027 seriously injured, approximately 1,000,000 left homeless and at least 329,000 houses were destroyed in the northwestern Yunnan province.						
1996	07	FEB	21:36	45.29N	149.89E	33		6.1	7.0	KURIL ISLANDS
				Some damage occurred on Iturup, also felt strongly on Kunashir.						
1996	17	FEB	05:59	0.95S	137.01E	33		6.4	8.1	IRIAN JAYA REGION
				At least 96 people were killed, approximately 45 injured, 54 reported missing and extensive damage on Biak and Supriori.						
1996	20	FEB	21:23	52.96N	2.26W	1	1.9			NEWCASTLE-U-LYME
				Felt throughout the Keele area of Staffordshire.						
1996	07	MAR	13:19	52.94N	2.25W	0	1.9			NEWCASTLE-U-LYME
				Felt throughout the Keele area of Staffordshire.						
1996	07	MAR	23:41	52.78N	2.74W	12	3.4			SHREWSBURY, SALOP
				Felt in Shrewsbury, Telford, Oswestry and Birmingham.						
1996	16	MAR	06:23	52.97N	2.29W	1	2.3			NEWCASTLE-U-LYME
				Felt throughout the Keele area of Staffordshire.						
1996	19	MAR	15:00	39.99N	76.64E	33		5.7	6.0	XINJIANG,CHINA
				At least twenty-four people killed, forty injured and more than 1,000 holmes destroyed in Jiashi County.						
1996	28	MAR	23:03	0.97S	78.69W	33		5.6	5.2	ECUADOR
				At least 19 people killed, 58 injured, several thousand homeless and considerable damage and destruction to homes, bridges and water pipes in the epicentral area.						

Issued by Bennett Simpson, British Geological Survey, April 1996

Forthcoming Events

25 September 1996
Structural Reliability in Earthquakes
Prof Baker, E Booth (SECED)
ICE 5.30pm

30 October 1996
Recent Research Topics in Soil Foundation Dynamics
Babtie Group Glasgow (SECED/BGS)

27 November 1996
Hazard Mapping (SECED) ICE 5.30

11 December 1996
Vertical Earthquake Ground Motion: Evidence, Effects & Simplified Analysis Procedures (SECED) ICE 5.30

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
Rehabilitation after Earthquakes SECED/EEFIT/EFTU

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

Contents

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 authors on request.

Articles should be sent to

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SECED

SECED, The Society for Earthquake and Civil Engineering Dynamics, is the UK national section of the International and European Associations for Earthquake Engineering and is an affiliated society of the Institution of Civil Engineers.

It is also sponsored by the Institution of Mechanical Engineers, the Institution of Structural Engineers, and the Geophysical Society. The Society is also closely associated with EEFIT, the UK Earthquake Engineering Field Investigation Team. The objective of the society is to promote cooperation 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.