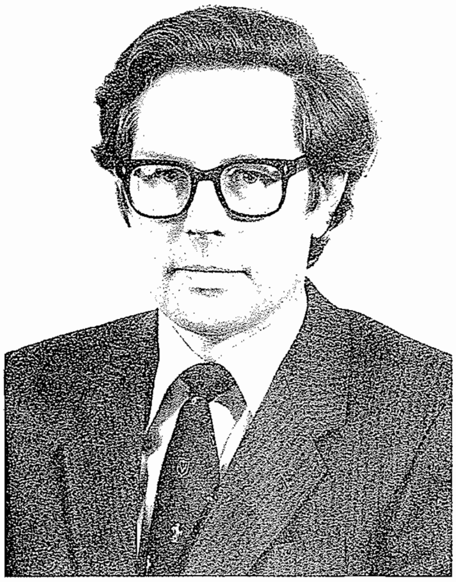
SECED NEWSLETTER

THE SOCIETY FOR
EARTHQUAKE AND
CIVIL ENGINEERING
DYNAMICS

October 1991, Vol. 5, No.4

SOCIAL SIGNIFICANCE OF SECED CONFERENCE

In his opening address to the SECED Conference Professor Norman Jones focused on the social importance of the conference theme - earthquake, blast and impact. In this extract, Professor Jones points to the ongoing role of SECED in the field of disaster mitigation.



The subject matter of the Third SECED Conference is very important to society because it embraces both natural hazards, such as earthquakes, and man-made hazards due to blast and impact, although impact may also be natural, as, for example, meteoroid impact and impacts due to rockfalls, etc..

The consequences of earthquake, blast and impact loadings on various components, structures and buildings are often very dramatic events which generate much public attention and media interest by occupying television news programmes and documentaries and newspaper headlines. Thus, SECED works in an area which is of vital interest to society.

With improved and rapid communications, the public are becoming increasingly aware, knowledgeable and concerned about various safety issues and many are demanding that greater priority should be given to the practical problems which lie behind the topics examined during this conference. The general public and politicians are also becoming much more interested in how research funds are spent and are increasingly demanding that more attention should be given to topics that are "socially relevant". Clearly, the topics in the SECED Conference programme fall into this category.

All professional or chartered engineers are aware that the proper application of current knowledge and the results from further research into outstanding problems would lead to improvements in safety and reductions in the loss of human life during accidents and disasters. The earthquakes in San Francisco and in Armenia about two years ago were similar in magnitude but caused totally different amounts of devastation and loss of life; the differences were about three orders of magnitude. This comparison illustrates that fundamental research into the scientific principles and their application to practical design and building can lead to dramatic improvements in the consequences of similar events.

Professional engineers who wish to design against the destructive action of earthquakes, blast and impact loadings need to estimate the maximum conditions which may be tolerated without catastrophic failure. The proper examination of these limiting conditions mean that many difficult non-linear dynamic problems are encountered, for example, finite-deflection effects or large geometry changes, large strains and material plasticity, variation of material properties with strain rate, such as the material strain rate sensitivity of the flow stresses, and the possible reduction of rupture strain with strain rate, which is usually ignored in theoretical and numerical calculations. Much more needs to be done in these and other important areas such as obtaining the appropriate scaling laws and their range of validity. Small-scale tests are necessary to reduce the high costs of full-scale testing because of the large dimensions of some of the practical structures in this field.

These questions and many others are addressed by the Conference - understanding of the subject matter will have been enhanced considerably by the end of the Conference. However, much more remains to be done so that we will be kept busy for many decades ahead. These Conferences will be a necessary stimulus to the development of this research and undoubtedly there will be a need for many more meetings organised by the Society for Earthquake and Civil Engineering Dynamics (SECED) in the years ahead.

Professor Norman Jones

Impact Research Centre
Department of Mechanical Engineering
University of Liverpool

More conference news inside, see page 9

EXPLOSION LOADING ON OFFSHORE STRUCTURES

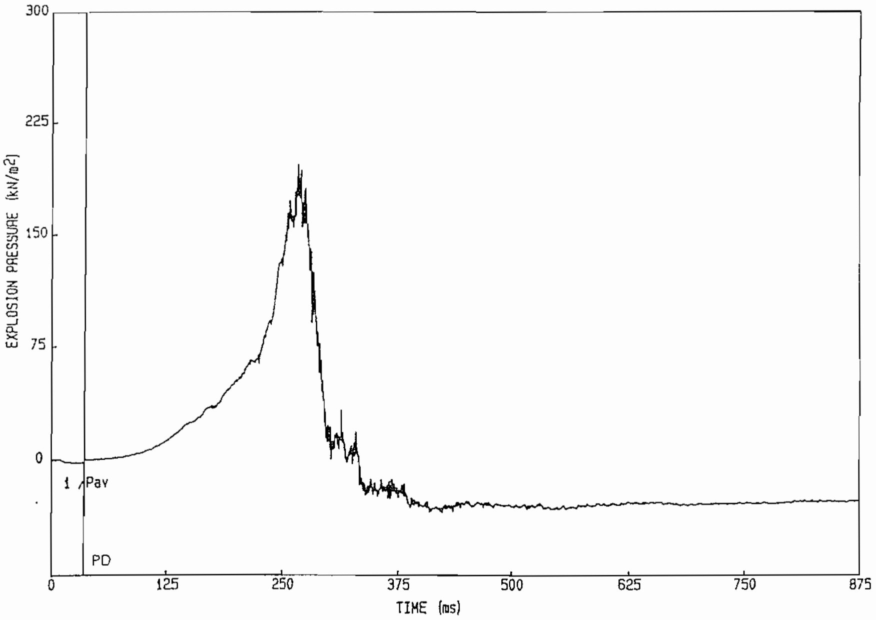
A Report from the Steel Construction Institute

Offshore oil and gas platforms process large volumes of hydrocarbon product in what can only be described as extremely confined conditions. This complex process facility normally sits directly adjacent to the platform control and accommodation module. There is thus considerable potential for a major incident, such as regrettably happened on the Piper Alpha platform.

Whilst it is desirable to try and prevent explosions and fires occurring, in practice it is impossible to completely eliminate the risk. The fire risk has always been recognised and platforms have been divided into separate fire zones which are designed to contain the fire, preventing it spreading to other areas of the platform. What has not been considered with adequate rigour in the past is the resistance of the platform to an explosion resulting from the ignition of a hydrocarbon release and build up. Indeed, very little was known about the magnitude of explosion loads, what factors affect it and how it may be efficiently designed against. This shortfall in our understanding has been recognised and there is now a significant research effort in this area.

An explosion results from the ignition of a flammable gas/air mix. A flame front spreads out from the point of ignition, heating the gas as it progresses which causes the gas to expand. If constrained from expanding, either by physical boundaries or by the inertia of the surrounding atmosphere, there will be an increase in pressure. Predicting the magnitude-time history of this pressure is one of the main thrusts of research effort today.

The factors affecting the pressure magnitude are the fuel type and volume, the resistance to venting of the explosion products and the rate of burning. The latter factor is least understood since in practice considerable turbulence is generated as gases expand past obstacles. This turbulence increases the flame front and hence the rate of burn and overpressures produced. This process can feed itself with more expansion and turbulence occurring as the explosion proceeds. There are at present only very limited models of this process.



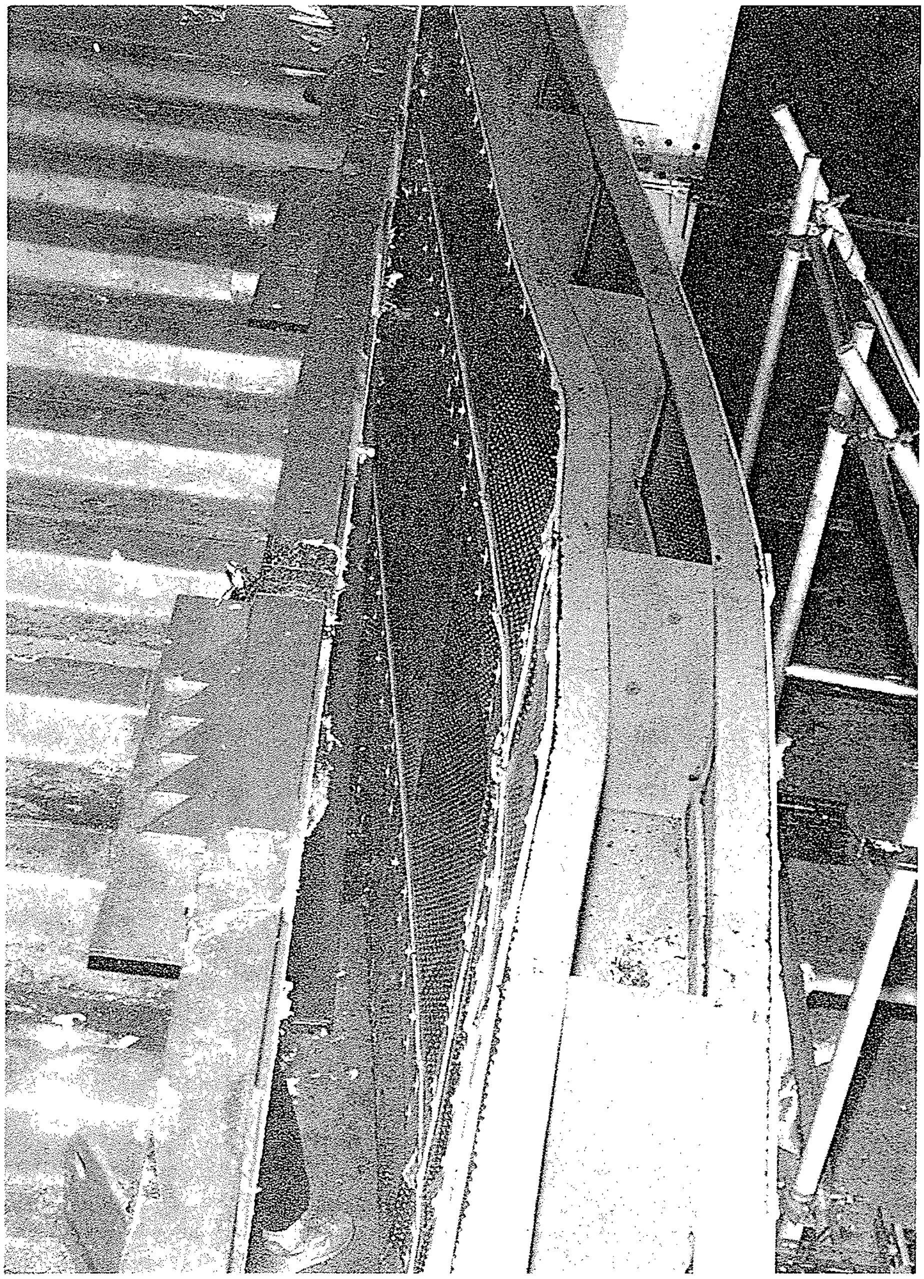
Example pressure time history developed in blast test rig at the Fire Research Station, Cardington

The structural engineer is primarily concerned about the shape of the pressure-time history for a particular offshore module. In particular, the maximum pressure magnitude, the rise time and the duration of the pressure wave are required. This enables the response regime of the structure to be determined. For example, if the rise time and duration are short relative to the natural period of structural members, then the explosion can be regarded as impulsive and direct energy methods rather than dynamic methods may be used to determine structural adequacy or damage.

For nearly all offshore structures the response of members to explosions is found not to be impulsive, but instead either quasi-static or dynamic. In the case of quasi-static response, the peak overpressure may be applied as a static load and members checked accordingly, usually with all code safety factors set to unity since an explosion is an extreme event. However, it is still necessary to check that there is no dynamic amplification caused by a short rise time. For this reason it is recommended that the response regime of a structure be determined from the rise time of the pressure wave and not the total duration.

Many members and structural assemblies on offshore modules are in practice found to respond in the dynamic regime. This means that it is necessary to use a dynamic solution procedure to determine the response and hence adequacy of a member.

The most commonly used method at present is to use a PC based single degree of freedom (SDOF) program. These have the advantage of speed but are limited to the analysis of only simple elements or sub-assemblies. SDOF analysis has thus been found adequate for the design of such items as blast resisting firewalls, which are deliberately isolated from the main



Cape Durasteel blast wall system showing plastic deformation of the supporting steel members (note that the wall has maintained integrity as a fire barrier)

structure, but is far less adequate for analysing the main structure itself. This requires the use of multi-degree of freedom programs based on finite element (FE) procedures.

The main problem offshore, and particularly for existing structures, is the magnitude of the potential explosion loading. This is sufficient to cause significant plastic deformation of the structure. The ability to allow plastic deformation has been built into many of the PC based SDOF programs and is in principle available with FE programs. However, the use of non-linear dynamic FE solution routines on large structures is an immense task, one which has almost totally precluded its use on offshore structures to date. There are further factors which complicate the design of offshore structures for explosion resistance. One of these is the effect of a high rate of strain which increases the instantaneous yield stress of steel.

Thus, as the structure responds dynamically to the applied explosion load, so the plastic resistance of the structure varies. In particular, at the transition between elastic and plastic behaviour, there is a marked increase in the rate of strain with a similar increase in structural resistance. This may be as much as 25% for normal structural steels. A problem in the design of structures responding dynamically and plastically to externally applied time varying loads is to determine a design failure criteria. Code checks based on elastic stress limits are clearly inadequate. The solution has been to propose a limiting deflection. This is based on a number of criteria, including the clearance between structure and equipment, strain tolerance of fire protection, and an absolute strain limit in the structural member. Such deflection criteria are normally acceptable for offshore structures because of the high quality and hence ductility of welding. Premature failure due to fracture, even at comparatively high rates of strain, is an almost non-existent problem.

This brief article has reviewed how explosion loading is currently handled in the design and re-assessment of offshore structures. It is a subject in which there are a number of problems, particularly the determination of the appropriate pressure-time histories. These problems have been identified in the first phase of a joint industry project managed by the Steel Construction Institute and sponsored by 29 oil companies. A second phase of the project is currently being launched with the specific intention of removing as much of the uncertainty as possible, particularly with regard to the explosion loading characteristics.

For further information contact :

Hugh Bowerman
Steel Construction Institute
Silwood Park
Ascot, Berks.
SL5 7QN.

SHAKING TABLE STUDIES OF DYNAMIC TORSIONAL COUPLING

Hinged joints have been developed by a team of researchers from University College London, for use in SERC-supported experimental inelastic dynamic response studies of modelled buildings. These units simulate the formation of plastic hinges either in the columns or in the beams of multi-storey buildings subjected to severe earthquake loading. The objectives, experimental set-up and initial results of an on-going series of tests are presented, relating to studies of the inelastic torsional behaviour of building models with varying mass asymmetry and different plastic hinge configurations.

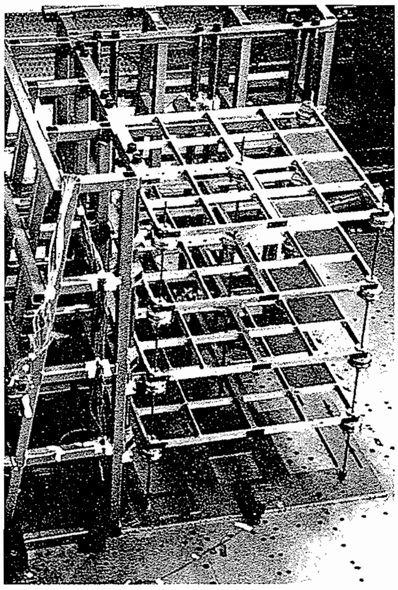


Fig 1 4-storey mass eccentric frame model with inelastic hinge units incorporated to simulate beam yielding (see Fig 6)

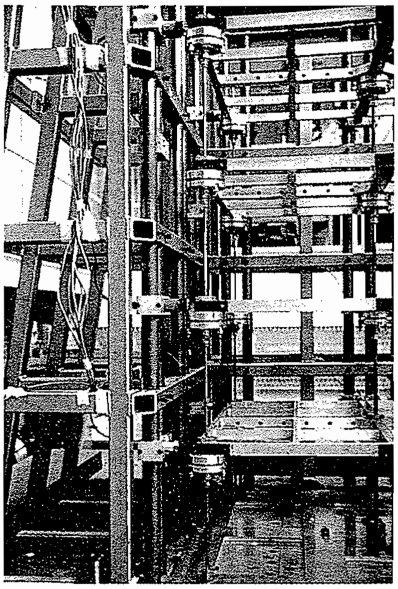


Fig 2 Non-contacting displacement transuced mounted on the 1st, 2nd and 4th floor levels.

Research Objectives

This research programme forms the second part of a study on the torsional behaviour of asymmetric buildings under seismic loading. For such buildings, the dynamic earthquake response is characterised by the phenomenon of torsional coupling, meaning that translational ground excitations result in both translational (or lateral) and torsional structural response behaviour. In the inelastic range, other parameters such as the strength eccentricity (distance between the centre of strength and the centre of mass) and yield strength distribution can significantly affect the behaviour.

The first part of this study focussed on elastic torsional coupling effects in multi-storey mass asymmetric buildings, and the experimental and analytical results have been presented in a series of publications (refs. 1-5). The current 3-year research programme (which commenced in October 1989) modifies the original elastic experimental model in order to accommodate inelastic structural behaviour through the use of hinges, which simulate plastic yield in the beam-column connections.

It is intended to provide valuable information and data on the behaviour of such buildings when they are loaded into the inelastic range of dynamic response. This is to be achieved by a combination of experimental and analytical research, with the ultimate intention of identifying what changes in the amplification of torsional response arise due to asymmetric yielding of structural load-resisting members, and how this compares with the elastic modal coupling evaluated in the earlier SERC-supported study, and with the numerous analytical studies available.

In the later stages of the current project, the results will be used to identify what geometric and dynamic characteristics of multi-storey buildings are advantageous when considering the effects of this type of coupling, and in particular what structural characteristics can be utilised to minimise or control the dynamic torsional response, by making practical use of the increased energy-absorbing capabilities of buildings undergoing asymmetric yielding to increase earthquake resistance.

Experimental Model

The building model used in this series of experiments consists of a multi-storey frame with five work-hardened brass columns, shown in Fig. 1 mounted on the SERC 6-axis earthquake simulator at Bristol University. The floors, measuring approximately 1 metre square, incorporate lead plates which can be placed in different configurations within the floor frame to alter the mass eccentricity of the building.

Displacements are measured by non-contacting tranducers mounted on rigid frames adjacent to the model (Fig.2). The column diameters in the model can also be varied to produce different ratios of torsional and translational stiffness. Recent studies have concentrated on a column configuration which has a ratio of torsional to

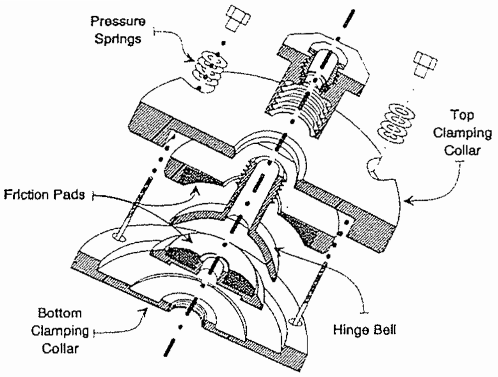
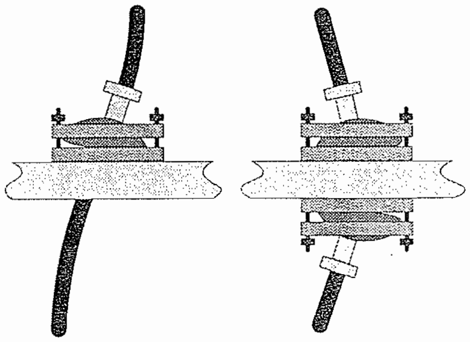


Fig 3 Exploded view of a typical inelastic hinge unit



Simulated Beam Yield

Simulated Column Yield

Fig 4 Hinge placement set-ups for the simulation of plastic yield in the beams or in the columns at floor level

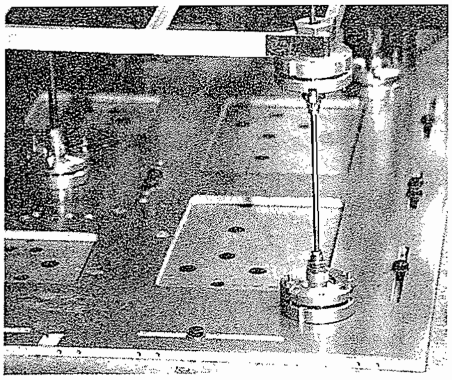


Fig 5 Dual hinge model for simulation of column hinge mechanism.

translational frequency near unity, a value which will generally lead to the greatest torsional coupling effects, particularly in the elastic range.

Hinge Joints

The hinge joint units consist of a set of brass clamping collars with detachable friction pads on a polished brass domed hinge cap (see Fig.3). The yielding moment in the hinge unit can be varied through an adjustment of the clamping force and through the use of different friction pad materials. The properties of the hinge units for various settings of the variable parameters have been presented and discussed in a paper at the SECED Conference in Manchester, September 1991 (ref. 6).

In studies of multi-storey buildings, the hinge units can be incorporated in the model at the column-floor connections in either of two set-ups (Fig.4). The column yield set-up consists of a hinge unit placed on both the top and bottom of each floor (Fig.5), and segmented columns attached to each hinge. This allows for a discontinuity in the column curvature at each floor, thus simulating the formation of a plastic hinge located in the column at the floor level. The beam yield set-up which has been extensively studied over the past year places a single hinge at either the top or bottom of each floor, and employs a continuous column through the hinge unit (see Fig.6 for the resulting deformation pattern in a typical 4-storey building). The resisting moment of the floor (beams) on the column is then limited to the plastic yield moment.

Results of the Work to Date

The 4-storey model without inelastic hinge units was tested on the SERC earthquake simulator in a previous study to assess the elastic response of a range of parametrically-defined frame structures with plan-eccentric mass distributions. The objective of this first study was to identify the combinations of the dynamic structural characteristics which cause the translational and torsional modes of the structure to couple significantly under earthquake loading, thereby increasing the risk of member failure or overall collapse due to overstressing in key structural elements such as peripheral columns.

In the first part of the current project, attention was focussed on the theoretical modelling of inelastic torsional coupling effects. The results have highlighted the sensitivity of analytical models of this phenomenon to variations in geometric layout and number of structural elements, the post-yield characteristics of the materials used in the construction, and the spectral characteristics and other properties of the ground motion. The results were published at the 9th European Conference on Earthquake Engineering in Moscow in September 1990 (ref.2). Another paper presented at the Moscow conference (ref.3) assessed the codified procedures for inelastic torsional response in comparison with analytical parametric studies of the problem, and identified certain inconsistencies and deficiencies in the procedures. Proposals are currently being formulated for improving the effectiveness of design procedures in the light of the obtained theoretical and preliminary experimental results. The priorities of the specification of such alternative design procedures are to improve their effectiveness in modelling actual behaviour as observed experimentally and in computer models, but without introducing unacceptable complexity. Another factor to be considered is to avoid the risk of over-design in an area where the evidence to date suggests that there is a wide variation of dynamic response due to the pronounced sensitivity to variations of structural and ground motion parameters.

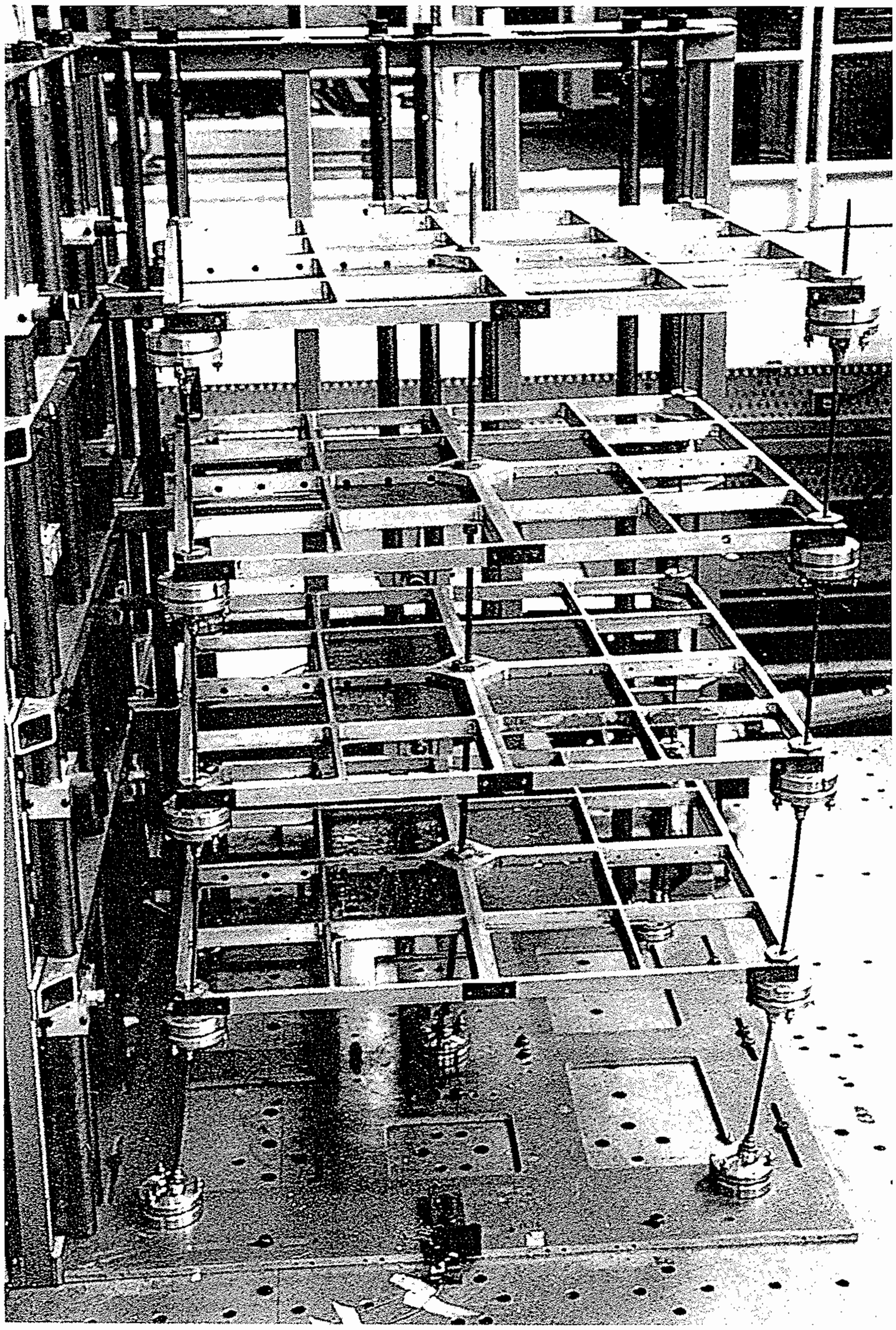
Future Studies

The final series of experimental tests will be performed in November 1991. These will investigate the inelastic behaviour of the 4-storey mass-asymmetric building model under conditions of column yielding and possible failure. It will then be possible to perform a comprehensive comparison of the results obtained for four separate series of studies (4-storey elastic, single-storey inelastic, 4-storey beam yielding and 4-storey column yielding) against analytical methods of analysis (see ref. 4 for a preliminary assessment). An assessment will be made of the inelastic performance of the hinge units (in terms of hysteretic energy absorption), and of the model (in terms of inelastic displacements). These will be compared with the elastic behaviour of such models, both experimentally and analytically, and will enable the effects of inelastic behaviour on asymmetric structures to be quantified more accurately, and in a form useful for design.

For further information about this study contact,

Adrian Chandler
Dept. of Civil Eng.
University College London
Tel. 071 387 7050

Fig 6 Lateral-torsional deformation pattern in a typical 4-storey asymmetric building with simulated beam hinging at the column-beam connections



Acknowledgement

This research programme is funded by the UK Science and Engineering Research Council (Grant GR/F/60632), whose support is gratefully acknowledged.

References

1. Chandler, A.M., Bassett, R.H. and Maheri, M.R., **'Initial Experience in Dynamic Torsional Coupling of Structural Models'**, SECED Conference on Civil Engineering Dynamics, University of Bristol, 123-140, 1988."

2. Bassett, R.H., Maheri, M.R. and Chandler, A.M., **'Torsional Earthquake Response of Frame Buildings to Eurocode 8 Spectrum Compatible Design Motion'**, 9th European Conference on Earthquake Engineering, Moscow, Vol.5, 97-106, 1990.

3. Duan, X.N. and Chandler, A.M., **'Torsional Coupling Effects in the Inelastic Seismic Response of Structures in Europe'**, 9th European Conference on Earthquake Engineering, Moscow, Vol.1, 162-171, 1990.

4. Chandler, A.M. and Nichol, E.A. **'Experimental Evaluation of Procedures for Earthquake Analysis of Torsionally Asymmetric Buildings'**, European Earthquake Engineering, Vol.4, No.3, 43-52, 1990.

5. Maheri, M.R., Chandler, A.M. and Bassett, R.H., **'Coupled Lateral-Torsional Behaviour of Frame Structures Under Earthquake Loading'**, Earthquake Engineering and Structural Dynamics, Vol.20, No.1, 61-85, 1991.

6. Nichol, E.A., Chandler, A.M. and Bassett, R.H., **'Design and Performance of Model Floor-Column Joints for Simulation of Inelastic Structural Response Under Earthquake Loading'**, SECED Int. Conf. on Earthquake, Blast and Impact Loading, UMIST, Manchester, September 1991.

A Review of Geoffrey Warburton's Mallet-Milne Lecture: REDUCTION OF VIBRATIONS

by Ray W. Clough

Opening Comments

In this thoroughly researched and carefully presented paper, Professor Warburton has made a major contribution to earthquake engineering literature. Before commenting on its content, however, I will raise an objection to its title because this title may not motivate earthquake engineers to read the paper. Probably a typical structural engineer will assume that it is concerned with the classical problem of diminishing machinery-generated vibrations in buildings and will not relate it to seismic excitation. In actual fact, though, the text is devoted to a topic at the cutting edge of earthquake engineering; this fact would have been suggested more effectively by a title such as "Reduction of Earthquake Response of Structures". This criticism is not a mere quibble because this title will detract from the recognition that the paper justly deserves among its true audience: the designers of earthquake-resistant structures.

In reading beyond the title, it is apparent that the purpose of the paper is to describe the principal types of systems presently being built into building structures to reduce the stresses and deflections induced in them by earthquakes applied to their base supports, and to compare the effectiveness of the various types of reduction systems. The paper begins with a summary of the equations expressing the linear elastic response of a simple single-degree-of-freedom (SDOF) structure subjected to base earthquake excitation. To simplify the presentation, the seismic input is characterised by its acceleration spectral density so the response may be expressed in terms of the system frequency response functions. This is the type of analysis that the developers and proponents of response reduction devices prefer; however, it would have been desirable for Professor Warburton to have pointed out that such analyses generally are valid only for structures operating within their linear elastic performance range. In actual fact, the response of the building or the reduction device may greatly exceed such limits, and it would have been useful to give some consideration to the consequences to the structure if the response limit were exceeded.

Four types of response reduction systems are described in the paper: (1) additional dampers, (2) base isolation, (3) passive vibration absorbers, and (4) active control systems. Comments are made here on each of these types, following the same sequence.

1. Additional Dampers

Additional dampers generally are incorporated in the structure in such a way that they have little effect on the response unless some critical response force or displacement is exceeded; when this happens, the device either slips or yields, thereby absorbing a significant amount of energy during each cycle of excessive response. Diagonal braces attached between the floors of a building are locations commonly used for the attachment of such dampers. In principle, they are arranged to act as if they were attached across a cut in the bracing member, resisting relative motion at the cut unless a threshold value of brace force is exceeded, thereby allowing the unit to slip or yield. Clearly such a device has little effect on the building behaviour when operating at lesser force levels.

Professor Warburton discusses results of both analytical and shaking table studies of structures in which such added damping devices have been installed. He notes that important reductions of response can be achieved by this system if it increases the total system damping from, say 2 to 20 percent of critical. However, it is apparent that such a damping increase will be obtained only in response to earthquake motions severe enough to activate the yield or slip mechanisms, and it is important to understand this limitation of the added damper protection system.

2. Base Isolation

By far the most widely used system of earthquake response reduction is base isolation - that is, by the installation of devices that effectively separate the structure from the input earthquake motions. Prof. Warburton has provided a very useful overview of this important field, drawing from recent papers that summarise the present state of knowledge on the subject and also presenting his own analysis of the earthquake behaviour of base isolated buildings. Included is information about the actual dynamic response of two base isolated buildings that have been subjected to earthquakes - one in California, the other in Japan. The data show that the responses of both these buildings were reduced materially by the base isolation.

To provide understanding of the expected performance of the base isolation systems, the paper discusses in detail a simple SDOF structure modified by adding base isolation. The equations of motion of the resulting SDOF system are presented, as are the equations for the frequency response functions that serve to characterise the response behaviour. Curves depicting the maximum structure acceleration, structure displacement, and base displacement as functions of the isolated system frequency clearly show the benefits of making the base isolation system soft, as would be expected. Using these same response function equations, Professor Warburton also discusses the influence of the structure frequency on the response function as well as its effect on the response to an earthquake motion represented by the Kanai-Tajimi spectrum. He shows that base isolation reduces the system response considerably so long as the structure frequency is not too great but for structures with frequencies approaching 6 to 8 Hertz the isolator tends to cause some increase in the structural response. Warburton also reports on the influence of the structure damping ratio and of the ratio of the mass of the SDOF structure to the mass at its base with regard to the response provided by the base isolation system to the Kanai-Tajimi earthquake input spectrum. These results should be of great value to anyone planning the installation of a base isolation system as part of a new or retrofitted building design.

3. Vibration Absorbers

It is noted by Prof. Warburton that vibration absorbers have a long history of applications for reducing mechanical vibrations, but that their use in civil engineering applications has been quite limited - especially in earthquake engineering. Essentially the vibration absorber is a spring-mass-damper unit which is attached to the point of maximum vibration of the structure under consideration. In an optimally designed system, often called a tuned mass damper, the inertial forces induced by this supplementary mass oppose the vibrations of the structure, thereby reducing their amplitude. As is clearly demonstrated by curves presented by Prof. Warburton, however, such absorbers are effective only for a very narrow input frequency range near that of the absorber, and they cause an increase of structural response outside of this range. Consequently, they do not appear to be appropriate for use as earthquake response control devices because of the broad frequency range of typical earthquake motions.

Prof. Warburton refers to an extensive body of analytical research which demonstrates the modest performance of vibration absorbers in limiting the response of an idealised multistory building to 48 different earthquake accelerograms. For a system having absorber mass two per cent of that of the structure, the absorber causes only a 17 percent reduction of structural response on the average. Additional studies done by Warburton show that the vibration absorbers perform slightly better in resisting earthquake motions defined by the Kanai-Tajimi spectrum, but the displacement response reduction in this case is still only about 35 percent.

4. Active Control

Professor Warburton's summary of the state of development in this relatively new field is especially valuable in the way he puts this potentially complex subject in perspective. He identifies the three principal concepts of active control: active mass drivers (AMD), active tendons (AT), and active variable stiffness (AVS), as well as variants in which any one of these is combined with a base isolation system. In all cases, both the base input acceleration and various structural response quantities are monitored and the required control forces are calculated according to appropriate control algorithms.

The most important application of an AMD system discussed by Professor Warburton is one installed by Kobori Research at the top of a 10 storey building in Tokyo. As noted by Warburton, this type of system is similar to a vibration absorber except that the mass added in the top storey is driven by hydraulic actuators in response to a computer generated signal rather than merely responding in free vibration. In designing this system, its response to a number of specified earthquake motions was determined analytically. After the building installation was completed, it was subjected to two earthquakes in 1989; the calculated response to the measured input was found to agree well with the measured response. The effectiveness of the system in controlling earthquake response was demonstrated by analytic comparison of the observed response with the system in place to what would have been expected without it. The reduction of response indicated by this calculation is noteworthy, except during the first one or two cycles after the ground motion started; displacements at the top of the building were indicated to be reduced more than the accelerations. Professor Warburton also reviewed an analytical study of a hybrid system in which an AMD has been added to a base isolated building model, in which it is shown that the AMD greatly reduces the motion of the isolated base relative to the ground as compared with the case without the AMD. However, as he points out, in this study the isolation system has very low damping and thus was not very effective. He notes that the response with the base isolation system acting alone would have been reduced by a factor of 10 if it had been properly damped, in which case the effectiveness of the AMD undoubtedly would have been greatly reduced. Also discussed in the paper is research done on active tendon systems and on active variable stiffness systems, in which the control forces are applied through diagonal braces in simple two-column frames subjected to uniaxial base motions. In some cases, the analytical studies were supplemented by shaking table model tests; however, these models were so simplified that they were merely physical analogues of the mathematical models. Another topic reviewed by Professor Warburton is the effect on system performance of time delays in the application of the calculated control forces. By analysis of a simple case, he provides a sense of scale to this analytically complex topic.

One of Professor Warburton's most important contributions to this subject of active control systems is a generalised discussion of the case with interstorey forces applied at each level of a multi-storey building. Considering a typical 20 storey building, he concludes that the required amplitude of active interstorey forces is very large - beyond any practical possibility. However, he also notes that if suitable base isolation has been installed, the required active interstorey forces are reduced to a feasible value. However, the ultimate conclusion is that the addition of active control to a properly base-isolated building is of questionable merit, the cost probably exceeding the benefit that it achieves.

Conclusion

In his concluding section, Professor Warburton compares the performance of the three passive methods of earthquake response reduction: vibration absorbers, added damping, and base isolation, and he concludes that base isolation is likely to be the most effective of these. Because of the relatively recent introduction of active control, he was not able to make a similar comparison for such systems; however, he made a valuable contribution by illustrating the theoretical potential and practical difficulties associated with active control. He has cited the Kobori Complex installation of active mass drivers in the Tokyo building as an example of practical active control. Unfortunately, however, he has not raised the question of its relative merit in comparison with a base isolation system, or even more importantly with the traditional direct approach of merely designing adequate seismic resistance into the building when its design is first planned. Strengthening of the structure and also designing for an acceptable degree of inelastic deformation are still viable concepts in earthquake engineering, worthy of consideration together with these new concepts. Of course these topics are well outside the scope of Professor Warburton's scholarly paper, and their absence does not detract from the contribution that he has made. This summary of methods for reducing the earthquake response of structures is a very valuable piece of work, and I am sure it will become a classic in the field.

Ray W. Clough
Professor of Structural Engineering
University of California, Berkeley
August 1991

Copies of the Mallet-Milne lecture publication are available from the Institution of Civil Engineers, London

CONFERENCE WRAP-UP

The third SECED international conference comprised 120 delegates, 14 exhibitors and 5 poster papers. Delegates from as far afield as Canada, Finland, Germany, Greece, Iran, Israel, Italy, Japan, Nigeria, Switzerland, Russia and New Zealand took part. Forty-two papers were presented over the 3 days, the presenters excelling themselves in sticking to a tough time schedule.

The proceedings of the conference have been published by Elsevier and were available to delegates at the start of the conference. A limited number of copies for sale at a special price to members of £50.00 remain. Please contact *Rachel Coninx at the Conference Office, Institution of Civil Engineers, Great George Street, London, SW1P 3AA.*

Apart from the technical sessions delegates were entertained by Manchester night life. On the Wednesday evening delegates were guests at a Civic Reception hosted by the Lord Mayor of the City of Manchester, Councillor George Chadwick, who christened the group the "crash, bang and wallop society", a title which is bound to stick ! The conference dinner was held in the unique surroundings of the Power Hall at the Museum of Science and Industry on Thursday evening. The sight, sound and atmosphere of the working engines, the surroundings for the meal, and the after dinner toasts by Brian Skipp and Corin Hughes-Stanton, will be a special memory for all who were there.

The organisation of the conference was a team effort, but special thanks must go to John McGuire for the effortless efficiency by which the proceedings were orchestrated. Special thanks also go to ICE Conference Office (Rachel Coninx, Nicola Kenwood, Barbara O'Donoghue), the organising sub-committee (Joe Barr, Chris Browitt, Ed Booth, Roy Kunar, Amr Elnashai, Scott Steedman, Peter Merriman), the session Chairman (sub-comittee plus Geoffrey Warburton, Brian Clarkson, Brian Skipp, David Key) and the opening speaker, Professor Norman Jones.

Thanks must also go to the authors for their stimulating presentations and the delegates for their lively discussion.

Finally thanks go to the conference sponsors, Ove Arup & Partners, W.S. Atkins, BGS and especially Lloyd's Register, who allowed John Maguire the time and resources to organise a truly excellent conference. The conference has been a special occasion and the society will be able to look back with pride and pleasure in years to come.

Conference organisers : Peter Merriman, Chris Browitt, Roy Kunar, John McGuire, Scott Steedman, Amr Elnashai, Edmund Booth, Nicola Kenwood and Rachel Coninx

NOTABLE EARTHQUAKES JULY - SEPTEMBER 1991

Reported by British Geological Survey

YEAR	DAY	MON	LAT	LON	DEP		MAGNITUDE		LOCALITY
					KM	ML	MB	MS	
1991	04	July	8.121S	124.656E	33		6.2	6.4	TIMOR
			Twenty three people killed, 181 injured and over 1,000 buildings destroyed at Kalabhi, Alor. At least 5,400 people left homeless and losses estimated at 7.7 million US dollars.						
1991	13	July	42.136N	125.610W	10	6.7	6.4	6.0	OFF THE COAST OF OREGON
			Felt throughout much of western Oregon and northern California						
1991	14	July	36.396N	71.139W	223		6.4		AFGHANISTAN - USSR BORDER REGION
			Felt strongly in northern Afghanistan and northern Pakistan						
1991	23	July	15.679S	71.582W	5		5.1	4.7	SOUTHERN PERU
			At least 12 people reported killed, 70 injured and 100 missing in the Mata area. Landslides in the area. A relatively small earthquake causing deaths and damage.						
1991	04	Aug	56.325N	4.432W	2	2.8			BALQUHIDDER, CENTRAL REGION, SCOTLAND
			Felt most strongly to the west of Loch Voil (VI MM). Also felt at Balquhidder, Crianlarich andGlenarich and Glen Dochart.						
1991	14	Aug	52.05N	3.535W	15	2.3			BRECON, POWYS, WALES
1991	17	Aug	41.606N	125.506	10	6.8	6.2	7.1	OFF COAST OF NORTHERN CALIFORNIA
			Felt (V MM) at Klamath, Rio Dell and Trinidad, Northern California and as far as Sacramento, California and Eugene, Oregon.						
1991	18	Sept	14.586N	91.040W	6		5.6	6.0	GUATEMALA
			At least 17 people killed, more than 100 injured and extensive damage in the Pochuta-Solola area. Many roads blocked by landslides near the epicentre. Felt (IV MM) at Guatemala City and at San Salvador (II MM). Another relatively small earthquake causing deaths and damage.						

Re-organisation of SECED Working Parties

The SECED Committee has undertaken a review of the activities of the Working Parties in recent years. In order to re-vitalise this activity and to have more involvement from the membership, the Committee has approved the following:

The formation of **Technical Reporting Groups**, to replace the Working Parties, with the objectives of (i) publishing in the SECED newsletter articles outlining activities in subject matters covered by each Group, including major industrial projects, research projects, conferences and recent publications, (ii) proposing topics for SECED meetings and undertaking their organisation, and (iii) organising technical workshops covering topical issues in their respective subject areas. The broad field of earthquake and civil engineering dynamics was divided into four topics, each covered by a **Technical Reporting Group**. Each Group is formed of a **Technical Reporter** and two **Reporting Group Members**. The Technical Reporter is necessarily a SECED Committee member, but at least one of the Group Members has to be from outside the Committee. The term of office for all members is two years, renewable. The formation of the Technical Reporting Groups is as follows:

Soil and Foundation Dynamics
Technical Reporter: *Dr. R.S. Steedman;* Reporting Group Members: *Dr. A. Chan and Dr. X. Zang*
Earthquake Engineering
Technical Reporter: *Dr. D. Key;* Reporting Group Members: *Dr. B. Evason and Dr. J. Newell*
Civil Engineering Dynamics
Technical Reporter: *Dr. B. Ellis;* Reporting Group Members: *Dr. M. Willford and Dr. A. Watson*
Engineering Seismology
Technical Reporter: *Dr. C. Browitt;* Reporting Group Members: *Dr. J. Bommer and Dr. D. McCann*

It is anticipated that the Technical Reporting Groups will play a very important role in SECED business and will be the focus of activities in the subject area. If any member has information or suggestions that he/she would like to bring to the attention of the Technical Reporting Groups, please contact the appropriate Technical Reporter.

EFFIT

Despite the lack of damaging earthquake events in recent months EFFIT has been extremely busy, using this breathing space to consolidate its position and bring its publication up-to-date.

EFFIT now publishes its own reports which are distributed through the good office of the Institution of Structural Engineers. At the recent SECED Conference in Manchester the EFFIT stand attracted considerable attention with its growing library of earthquake reports. These now cover.

Chile	1985
Mexico	1985
San Salvador	1986
Newcastle, Australia	1989
Iran	1990
Phillipines	1991

With Loma Prieta at the review stage and Romania and Sicily in the pipeline. Many authors have contributed to these reports and as successive field investigations are mounted, lessons have been learnt both on practice in the field and on publications.

One of the Committee's goals this year has been to revise the Objectives and Methods Statement in the light of this field experience, gained over what is now nearly a decade of operations.

The new Objectives and Methods Statement is intended to be distinct from constitutional matters, but provides guidance to the EFFIT Committee and to the prospective field team in the crucial days between the news of a disaster and the setting up of operations in the field. Why send a team? What will they do ? Who should go ? Who will pay? How will they work withlocal contacts ? Each earthquake will be different and on each occasion these same issues must be reviewed afresh.

The underlying issue, however, is one of funding. It is one of my own goals to achieve some financial base for EFFIT to operate from. This will be achieved in part by the generosity of sponsoring companies who assist in the publication of reports, but also from subscription and perhaps ultimately from participation in a joint European research programme.

EFFIT is in a strong position. Its track record of reports is excellent; its members include many of the well-known figures in the UK earthquake engineering field; above all its strength lies in the range of institutions from whom the individual members are derived. We are always keen to welcome new members, either corporate or individual.

Dr R Scott Steedman
Chairman, EFFIT

Requests for publications or membership should be sent to,
Mr A K A Lorans
Secretary EFFIT
The Institution of Structural Engineers
11 Upper Belgrave Street
London, SW1X 8BH

BOOK REVIEW PRIZE

An annual award is offered for the best book review published in the SECED Newsletter.

A prize of £25 (sponsored by Allott & Lomax) will be awarded to the best book review published in the SECED Newsletter. This annual competition will start January 1 1992 and is open to all members, especially student members. Only reviews published in the Newsletter will be eligible for entry and the award will be granted solely at the discretion of the Newsletter editor, and judging panel.

Contributitors should send their reviews to,

The Secretary
SECED
The Institution of Civil Engineers
1-7 Great George Street
Westminster, London
SW1P 3AA

LOGO COMPETITION

Roll out the Old

Can you improve your society's logo?

Your committee has decided to promote a competition to design a new logo to represent the Society for Earthquake and Civil Engineering Dynamics. A prize of £25.00 will be awarded to the member who, in the committee's judgement, submits the best logo. The winning design will be used on future SECED publications.

Please send all entries to:

The Secretary
SECED
The Institution of Civil Engineer
1-7 Great George Street
Westminster, London.
SW1P 3AA

Closing date for entries
14th January 1992.

LIBRARY AQUISITION

Proc, 1st Int. Conf. Seismology and Earthquake Engineering received from IIEES, Iran. Available from ICE library.

WHAT'S ON

October-December 1991

30th October 1991
SECED Meeting
Measured Effects of Wind Dynamics on Buildings
Institution of Mechanical Engineers

5th November 1991
Plant Design for Seismic Conditions
Institution of Mechanical Engineers

4th December 1991
Joint SECED/ICE Hazards Forum
Earthquakes :Impact on the Community
Half-day public meeting
Institution of Civil Engineers

FORTHCOMING EVENTS

22th January 1992
SECED Meeting
UK Work Related to Eurocode 8
Chairman : Dr. B. Skipp
Institution of Civil Engineers

27th January 1992
Joint SECED/British Dam Society Meeting
Dams and Seismic Effects
Institution of Civil Engineers

26th February 1992
SECED Meeting
Blast and Impact
T.J. Wilton
University of Nottingham

9th-11th March 1992
Norwegian Petroleum Society
Seismic Processing
Kristiansand, Norway

25th March 1992
Joint SECED/EEFIT/EFTU Meeting
Reports from the Field of Recent Earthquakes
Institution of Civil Engineers
also EEFIT AGM

25th-27th March 1992
ESG 1992
International Symposium on Effects of Surface Geology on Seismic Motion
Odawara, Japan.

31st March - 2nd April 1992
National Engineering Laboratory
Conference on Structural Integrity Assessment
University of Manchester

29th April 1992
SECED Meeting
Report on the Work of Bristol Shake Table and Pseudodynamic Testing at Imperial College
Imperial College, London
also SECED AGM

27th May 1992
SECED Meeting
Validation of Geotechnical Computer Codes by Centrifuge and Shaking Table Tests
Cambridge University

28th - 29th May1991
Association of Chartered Engineers in Iceland
Natural Disasters '92
Reykjavik, Iceland

19th - 25th July 1992
Tenth World Conference on Earthquake Engineering,
Madrid, Spain

20th - 23rd July 1992
Institution of Civil Engineers
International Conference on Retaining Structures
Cambridge

19th - 20th August 1992
ASCE Structural Division
Symposium on Dynamic Analysis and Design Considerations for High-Level Nuclear Waste Depositories
San Francisco, California

RECENT PUBLICATIONS

"The SECED Directory - A Directory of Practitioners in Earthquake Engineering and Civil Engineering Dynamics," Issue No. 3, September 1991.

"Engineering Aspects of the Manjil (Iran) Earthquake of 20 June 1990", A Field Report by EEFIT.

"Engineering Aspects of the Newcastle, Australia Earthquake of 28 December 1989", A Field Report by EEFIT.

"The Luzon, Philippines Earthquake of 1990", A Field Report by EEFIT.

"Friction Load Control Devices for Steel Braced Frames", G.Anagnostides, A.C. Hargreaves and T.A. Wyatt, Report ESEE-90/3, June 1990.

"The Chenoua (Algeria) Earthquake of 29 October 1989", N.N. Ambraseys, A.S. Elnashai, J.J. Bommer, F.Haddar, P.Madas and J.Vogt, Report ESEE-90/4, July 1990.

"A New Passive Confinement Model for Concrete Subjected to Variable Amplitude Cyclic Loading", P. Madas and A.S. Elnashai. Report ESEE-91/2", March 1991.

"An Analytical Approach to Seismic Energy Absorption of Steel Frames with Random Material Characteristics", K. Koh, A. S. Elnashai and M. Chryssanthopoular, Report ESEE-91/3, April 1991.

"Long-term Seismicity of Istanbul", N.N. Ambraseys and C.Finkel, ESEE-91/8, July 1991.

"Earthquake Resistant Design of RC Walls", K. Pilakoutas, supervised by A.S. Elnashai and N.N. Ambraseys, Report ESEE-91/4, April 1991.

"Database of European Strong Ground Motion", N.N. Ambraseys and J.J. Bommer, Report ESEE-91/5, April 1991.

"Attenuation of Peak Ground Acceleration for Europe", N.N. Ambraseys and J.J. Bommer, Report ESEE-91/6, May 1991.

"Seismic Behaviour of Reinforced Concrete Walls with Low Shear Ratio", M.S. Lopes supervised by A.S.Elnashai, Report ESEE-91/9, September 1991.

SECED NEWSLETTER

The SECED Newsletter is published four times a year by the SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS. The Newsletter is issued in January, April, July and October and contributors are asked to submit articles as early as possible in the month preceding the date of publication. Manuscripts should be sent typed on one side of the paper only, and a copy on a PC compatible disk would be appreciated. Diagrams should be sharply defined and prepared in a form suitable for direct reproduction. Photographs should be high quality and black and white prints are preferred wherever possible. Diagrams and photographs are only returned to authors upon request. Articles should be sent to Nigel Hinings, Editor, SECED Newsletter, Allott & Lomax, Fairbairn House, Ashton Lane, Sale, Manchester, M33 1WP, United Kingdom (Tel. 061 962 1214; Fax 061 969 5131).

Production by Allott & Lomax, Manchester.