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THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

SECED NEWSLETTER

April 1993, Volume 7, Number 2

"Liquefaction and all that"

Above: Professor Ishihara delivering the 33rd Rankine Lecture to a packed auditorium at Imperial College, London

The Thirty-third Ranking Lecture, delivered by Professor K Ishihara on the subject of liquefaction, was of only a few in the Rankine series to specifically address earthquake problems. Delivered with his characteristic sense of humour, Professor Ishihara skilfully wove his way through the maze of historic liquefaction research to present a clear and definitive summary of the state of the art in the prediction of liquefaction on level ground using site data.

The phenomenon of liquefaction of saturated soil deposits as a result of earthquake shaking has been reported in numerous earthquakes and been associated with a great variety of hazards including: sand boils, flow failure of slopes and earthfill dams, loss of bearing capacity, settling and tilting of buildings, buoyant rise of buried structures etc.

The dramatic consequences of the loss of bearing capacity and subsequent settling and tilting of buildings brought the subject forcefully to the attention of the engineering community following the Niigata earthquake in Japan (1964). To introduce the subject, Professor Ishihara showed some remarkable video footage of liquefaction taken at the time.

Much effort has been expended in recent years in the measurement of the residual strength of sand in undrained uniaxial compression. These laboratory studies have been widely reported but not until now have they been successfully linked into the empirical observations of

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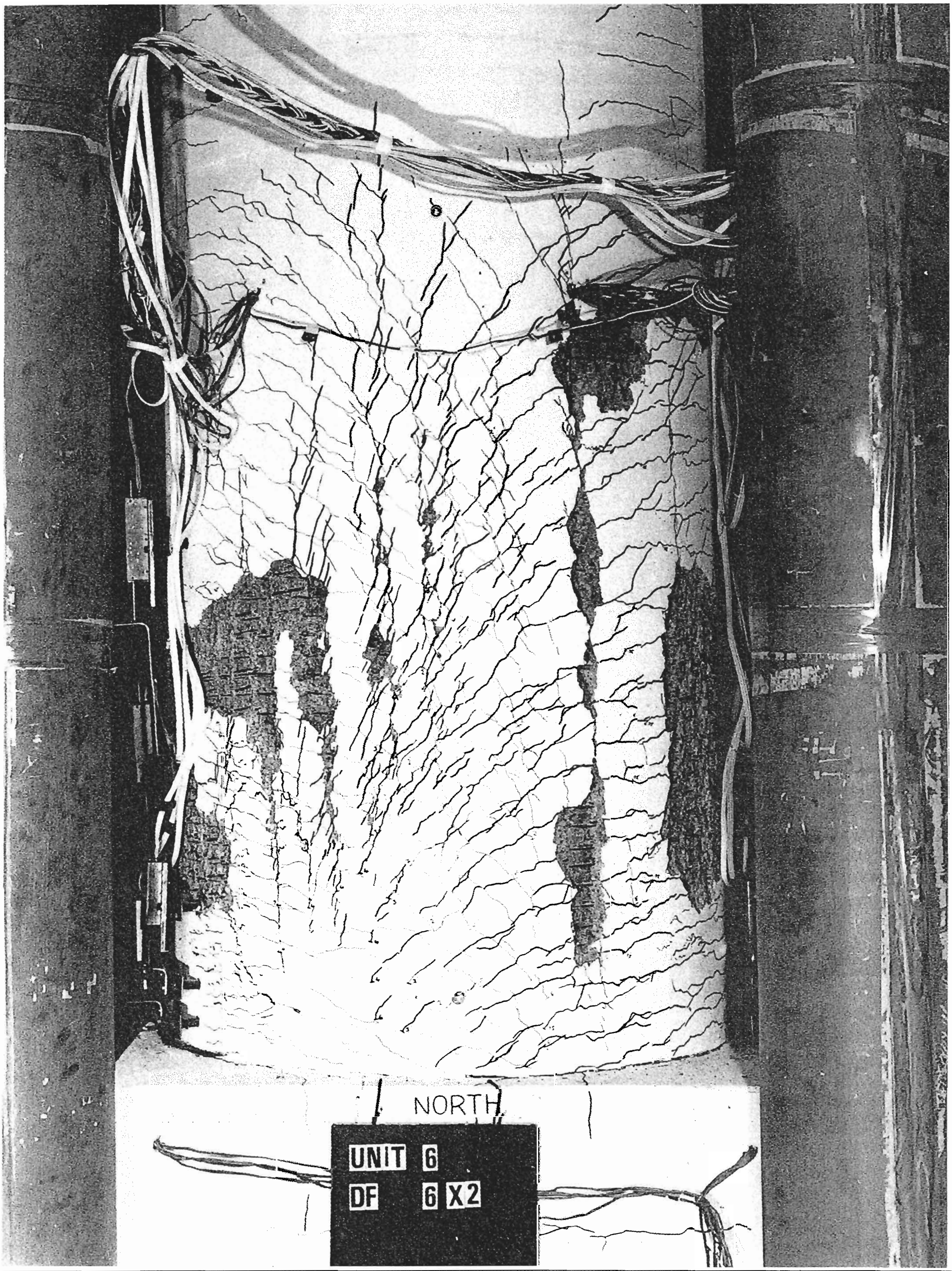


Diary note - ***5.00pm, Wednesday 26th May 1993***
Institution of Civil Engineers
Professor Thomas Paulay: Simplicity and Confidence in Seismic Design
The Mallet Milne Lecture
+ Reception

'Liquefaction...' continued from page 1

liquefaction based on SPT and CPT data. This novel work is very welcome, and completes a missing part of the liquefaction jigsaw.

Using field observations of liquefaction in historic earthquakes in Niigata (1964) and at Akita Port during the Nihonkai Chubu earthquake (1983) linked to site investigation data of blow count or cone resistance, Ishihara was able to explore the behaviour of sands of very low relative density and compare their field behaviour with laboratory testing of clean sands.

To achieve laboratory samples of sufficiently loose sand, he noted the significant difference in density and fabric achieved by moist tamping, dry deposition and pluviation in water. Observations of stress-strain behaviour show clearly that some very loose samples exhibit an initial peak strength before collapsing to a residual condition. Denser samples exhibit dilative behaviour with strain-hardening until ultimately a steady state condition (analogous to critical state) is reached, which will be similar for both.

Soil collapsing to a residual strength can clearly lead to large deformations, sometimes referred to as a flow-failure. The breakdown of loess deposits with an unusually high water content under low level shaking in the Dushanbe earthquake (1989) showed clearly how the release of water can rapidly degrade a soil structure and fluidise large masses of material. Can the flow condition be linked to routine site investigation data?

Ishihara described how empirical relations such as those published by Skempton (1986) relating blow count to relative density (and hence to void ratio) could be used to link effective confining stress to blow count as a function of the "initial state ratio, r_c, of the particular sand under consideration.

The initial state ratio is itself a function of the maximum excess pore pressure generated in undrained shearing. A high value indicates that the soil has a tendency to lose almost all its strength (in a "quasi-steady state") before dilation sets in under very large strains in laboratory tests. However if this ratio is below around 2 then the soil is relatively well behaved and unstable flow is unlikely. This boundary between contractive (unstable) and dilative (stable) behaviour is particularly helpful if it can be mapped as a function of standard site investigation data, such as SPT or CPT.

Turning then to consider the minimum or residual shear strength of sands, normalised by the initial effective vertical stress, Professor Ishihara plotted out the predicted envelope of flows vs no-flow behaviour, noting the very low SPT values associated with this condition. To complete the picture, and to place the flow/no flow condition in proper context, he then superimposed the early work of Seed and others in cyclic strength to create a general map of liquefaction vs no liquefaction and, in the very low strength region, flow vs no-flow as a function of blow count or cone resistance.

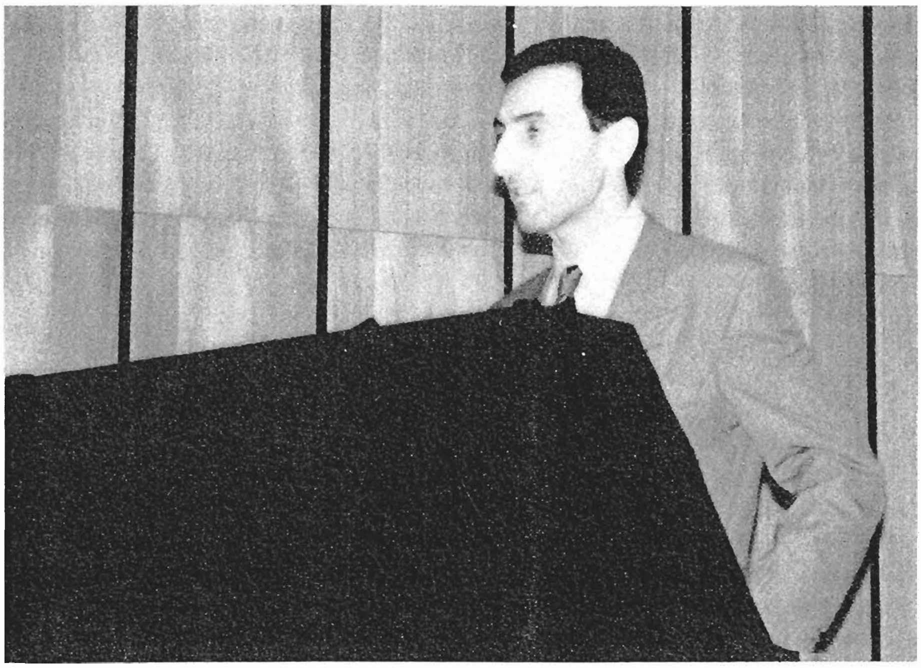
In comparison with data from in situ observations in the field, laboratory based studies of the cyclic strength of clean sands showed a lower threshold for liquefaction, and therefore might be considered a lower bound to the data. The novel feature of this work, however, was the linking of the flow condition to SPT and CPT data.

The guidance this approach will provide for geotechnical engineers trying to interpret site investigation data will be very beneficial and the structure of this approach will certainly be built upon in the future for use in the field, incorporating silty sands and the use of further CPT data.

This was an excellent evening which Professor Ishihara neatly rounded off by noting the long standing connection between his own institution of the University of Tokyo and Professor Rankine. Professor Ishihara's outstanding contribution to geotechnical earthquake engineering, and his diplomacy, shone through the lecture, to great and well deserved acclamation.

Dr R S Steedman
Sir Alexander Gibb & Partners Limited

The Thirty Third Rankine Lecture was organised by the British Geotechnical Society. Professor Ishihara's paper Liquefaction and Flow Failure during Earthquakes will be published in the September edition of Geotechnique. For information contact Kevin Aston at the Institution of Civil Engineers, London.



Right: Dr Amr Elnashai, Chairman of SECED, introducing Professor Ishihara in impeccable Japanese at the Rankine Lecture

THE ERZINCAN EARTHQUAKE: AN UPDATE

by Martin Williams
University of Oxford
Department of Engineering Science

The 2nd Turkish Earthquake Engineering Conference in Istanbul was timed to coincide with the first anniversary of the Erzincan earthquake of 13 March 1992. This magnitude 6.8 event, which caused severe damage and hundreds of deaths, was the subject of an EEFIT field mission featured in a previous SECED Newsletter (Vol 6, No 2). As a result of the Erzincan disaster, interest in earthquake engineering in Turkey is at an all-time high. As well as the large number of Turkish participants there was a strong international contingent at the conference, including delegates from the USA, France and eastern Europe. The EEFIT team was represented by Martin Williams.

The Turks were obviously deeply shocked by last year's events, and were perhaps awakened from a certain amount of complacency. In the opening session, the governor of Istanbul spoke graphically of the scale of disaster that could result from an earthquake striking his own city, where the general quality of construction is certainly no higher than in Erzincan. Oktay Ergunay, head of the Directorate of Disaster Affairs admitted the almost complete lack of building controls during the recent Turkish economic boom, and the failure of the authorities adequately to coordinate the disaster response. He was also rather critical of foreign relief teams, whose lack of prior communication with the Turkish authorities severely reduced their effectiveness.

A year after the earthquake there is still some dispute over the exact location of the epicentre, but it is thought to be about 8 km from the centre of Erzincan. Even more uncertainty persists over the focal depth, with the majority of seismologists suggesting a value of 26 to 28 km, but several speakers proposing much lower values. Aykut Barka, the leading authority on the tectonics of the Erzincan Basin, claimed that the risk of serious earthquakes in the region had actually been increased by last year's event, making the detailed instrumentation of the fault region extremely important. However, funding for monitoring of aftershocks was cut two months after the earthquake, even though seismic activity was not reducing.

The controversial issue of soil amplification effects within the deep, alluvial Erzincan Basin was widely discussed, with both seismological and structural evidence presented. While no borehole information deeper than 200 m is available, most researchers now seem to agree that the basin is around 1200 m at its deepest point. However, estimates of the basin depth in the city centre range from 400 m to 1000 m! The most convincing argument for a significant basin effect was the aftershock monitoring carried out by the USGS, which showed a clear increase in acceleration amplitudes towards the centre of the basin in the frequency range 0.5 to 4.5 Hz. However, researchers from Istanbul Technical University suggested that the presence of a very dense gravel layer quite near the surface dominated the soil response, with underlying sediments having little effect. The structural data presented, including that gathered by EEFIT, did not show any clear trends in damage levels across the basin.Most of the structural papers concentrated on damage to reinforced concrete buildings, although EEFIT observed that other structural types also performed badly in the earthquake. One of the major problems appears to have been concrete quality; it was asserted that the average concrete strength was between 40 and 50% of the minimum required by the Turkish earthquake code, and that only 1% of concrete actually exceeded this minimum strength. However, these figures appeared to be based solely on testing of buildings which performed badly in the earthquake.

The Turks are now engaged in a lively debate over whether their code needs substantial revisions or just better enforcement. My own view is that, while some changes are desirable, enforcement is of primary importance. However, in Turkey the revisionists seem to have the upper hand. The two principle code issues that were aired at the conference were the choice of the equivalent lateral design load (particularly the treatment of site response effects) and the provision of shear walls in concrete frames.

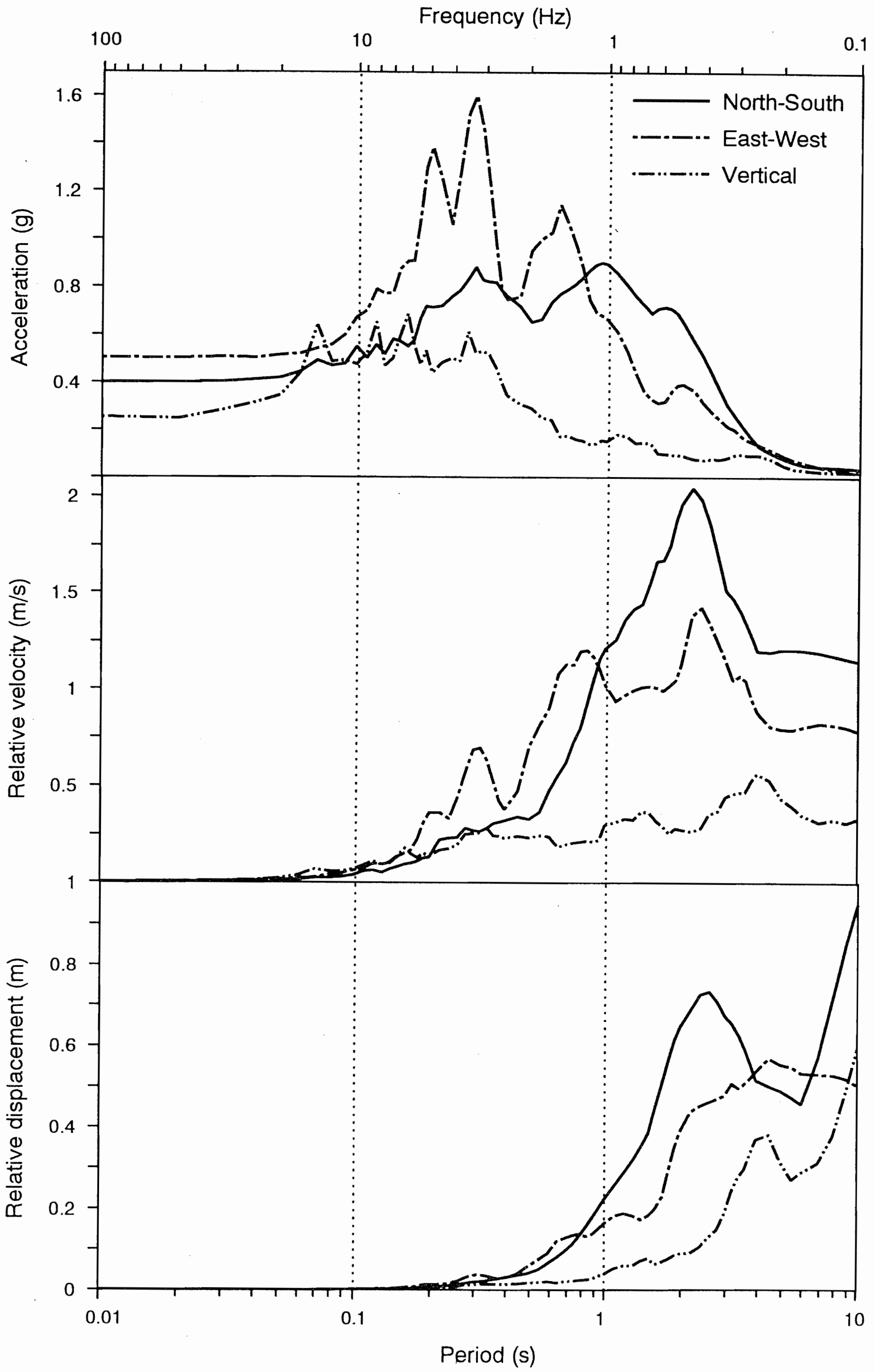
On the former topic, the 1992 draft revisions of the Turkish code (not yet in force) suggest minor modifications to the calculation procedure, which have only a small effect on the lateral load coefficient. Tezcan, in an excellent paper, compared the requirements of various codes for a building with a natural period of 0.3 seconds, situated on medium soil in a high risk zone. The 1975 Turkish code gives a lateral load of 10% of the weight, while the 1992 draft gives values of 8 or 12%, depending on the ductility. The UBC, New Zealand, Japanese and Russian codes all give considerably higher values, between 18 and 21%. Regardless of the code requirements, new buildings in Erzincan are being designed for a value of 15%.

In the case of shear walls, there are suggestions for some very stringent requirements. Middle East Technical University, who are supervising much of the reconstruction, require the provision of shear walls having a cross sectional area exceeding 1% of the total floor area, and it is possible that this figure could be adopted in the new code.

Repair and reconstruction in Erzincan is now well underway. Many school buildings and housing blocks have already been repaired or rebuilt and, after a break necessitated by the region's very severe winter, work is about to commence on the hospitals, government buildings and further housing. Repair often involves enhancing the structural strength to a level well in excess of its value before the earthquake, usually by the strengthening of columns and the provision of shear walls over the full height of the building. Where repair is possible, the cost is approximately 30% of the cost of demolition and reconstruction.

A presentation of the work carried out by EEFIT at Erzincan was very well received. The damage surveys we performed differed quite substantially from those carried out by other teams, and made a useful contribution to discussions of the basin effect and of the performance of different structural types.

Clearly we are still some way from fully understanding what happened at Erzincan, and the data gathered last year will keep researchers busy for some time. However, in the short term it is necessary to rebuild the city quickly, economically and, above all, safely. Clearly there is the will and the ability to do this, but already there are signs that funding promises may not all be kept, and that enforcement will not be tightened up sufficiently. If that is the case then the future of many Turkish cities looks perilous.



Above: 5% damping response spectra of strong motion record captured at the Erzincan ground response station approximately 10km from the earthquake epicentre (MS=6.8; R=27km)

The Erzincan Turkey Earthquake of 13 March 1992: A Field Report by EEFIT can be purchased from Andy Lorans, Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1X 8BH (Tel: 071 235 4535).

SECED Meeting

SEMI-RIGID STEEL FRAMES

The "Semi-Rigid Steel Frames" seminar organised by SECED attracted an audience from industry as well as academia; we had a full lecture theatre. The speakers were introduced by Dr Amr Elnashai (Imperial College) who also made opening comments on the background to the revived interest in semi-rigid steel frame design. Professor David Nethercot (University of Nottingham) presented the main parameters affecting the static response of this type of construction. This was followed by Dr Ahmed Elghazouli (Imperial College) who focused on aspects of seismic performance and David Naylor (British Nuclear Fuels) as a potential client. Dr Allan Mann (Allott & Lomax) closed with a statement from an experienced designer.

Below, brief technical notes, comprising contributions from the speakers, describe the contents of the presentations and the main issues involved in static and dynamic response and design of steel frames with semi-rigid connections.

Static Response

It has long been realised that all practical forms of steelwork connection actually function in a way that is intermediate between the normal design bases of "pinned" and "rigid". For example, tests conducted in the early part of this century on riveted beam-to-column connections showed quite clearly that these possessed a significant rotational stiffness. However, the moment capacity was found to be rather less than that of the beams involved. This led to the identification of the moment-rotation (M - θ) characteristic as being the key to understanding the effects of joint behaviour on the performance of frame structures. Early work concentrated on the behaviour under monotonic loading. The figure below depicts normalised M - θ curves for three types of connection subjected to monotonic loading.

Methods were found to represent M - θ curves and to incorporate these into analyses of the response of individual components (beams and columns) and complete frames. Initially this work was confined to two-dimensional behaviour but both the non-sway and sway cases were examined. More recently, full three-dimensional response has been investigated, especially in the case of columns where the complex moment shedding associated with actual failure has been related to that observed previously in rigid jointed construction. The verification of the analytical/ numerical work against the results of large-scale testing has confirmed its validity. A full-scale test specimen was tested at the Building Research Establishment and this provided data for the calibration of analytical models.

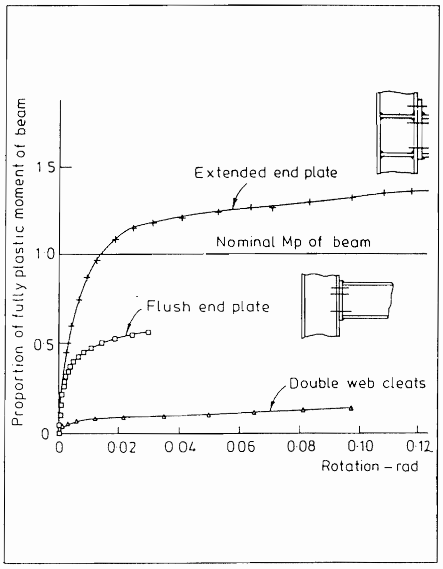
Despite its inclusion in early steelwork codes e.g. BS 449, exploitation of semi-rigid joint action in design has not been popular. However, considerable progress has been made in the past decade in developing an improved understanding of the subject and this is reflected in its treatment in the recently published EC3. Recognition that frame behaviour is intimately linked to the performance of the connections has led to the ideas of classification of connection behaviour and to specification of the key joint parameters of moment capacity, initial stiffness and rotation capacity. Work continues on methods of predicting these properties.

Parallel studies have also been conducted into the effects of composite action on the performance of connections and frames - although this work is less well advanced. However, the potential for more satisfactory structural performance is greater due to the particular problems raised by matters such as the differences between the hogging and sagging moment capacities of composite sections, the greater importance of local buckling in certain instances etc. EC4 therefore permits utilisation of semi-rigid joint behaviour but does not attempt to provide such a detailed treatment.

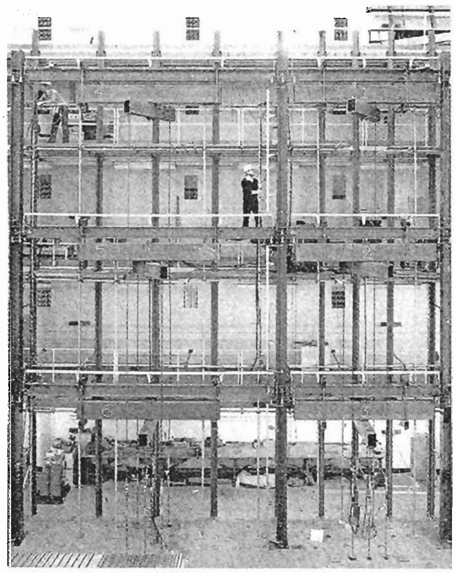
Much work is still needed to provide detailed design guidance in code-format. This should cover not only the connection, but also characteristics of the members framing into it which are affected by connection characteristics.

Seismic Response

For earthquake-resistance, semi-rigidly connected frames are considered to be inappropriate mainly



Right: Typical moment-rotation curves for semi-rigid connections



Centre: A full scale semi-rigid frame tested in the large structures facility at the Building Research Establishment due to their excessive flexibility. Their advantages, in terms of lower construction costs and simple fabrication, are therefore not hitherto utilised in seismic design. On the other hand, reliance on the rigidity of fully-welded connections under earthquake loading has recently come under question, particularly in Japan, as a consequence of difficulties associated with quality control of welding processes. This casts doubts over the integrity, hence reliability, of this type of construction when subjected to severe inelastic cyclic straining.

Recent analytical and experimental work has indicated that semi-rigid frames may be used to advantage in low and medium seismicity zones. Comparative experiments indicated that the rigid frame is by no means the optimum solution, and that semi-rigid designs may perform adequately under simulated earthquake loading. Semi-rigid frames have the advantage of a longer period hence attract lower inertial loads. This may offset the effect of the increased flexibility, hence resulting in a most satisfactory earthquake-resistant design solution, even in areas of high peak ground parameters.

In order to provide detailed information of the seismic response parameters of semi-rigid frames in comparison with fully-welded alternatives, recent experimental work was undertaken (within part of an ongoing joint earthquake engineering research programme between Imperial College, London, and the Institute of Industrial Science, Tokyo) on two storey single bay steel frames. Monotonic, cyclic and on-line pseudo-dynamic earthquake loading on five two-storey steel frames were performed, with particular attention directed towards understanding the comparative behaviour of the rigid and the semi-rigid frames. A general view of the testing assembly is shown in the photograph below.

A component-based model, developed at Imperial College, and implemented within the non-linear dynamic program ADAPTIC, was verified against the results of the experiments. The model represents the non-linear cyclic behaviour of the connection with the prior knowledge of only the geometric and strength parameters of the constituent components. It is based on assembling the overall connection response from component contributions and accounting for shear panel deformations and bolt slippage. The analytical model was used to investigate, through simple examples, the effect of connection type on important seismic response parameters of steel members and frames, such as capacity, effective length and plastic hinge length.

The main conclusion of the experimental and analytical studies carried out within this investigation was that semi-rigidly connected frames demonstrate adequate, and in some cases, favourable earthquake-resistant qualities. It was shown that semi-rigid frames do exhibit ductile and stable hysteretic behaviour. Although the stiffness and capacity of semi-rigid frames are lower than similar rigid frames under monotonic and cyclic loading, the response under earthquake loading largely depends on the dynamic characteristics of both the frames and the input motion. In many cases, the performance of semi-rigidly connected frames may be superior to rigid frames, provided that stable hysteretic behaviour is ensured.

Industrial Requirements

The nuclear industry is a major client for high integrity, earthquake resistant steel framed structures in the UK. Over the past decade BNFL have used approximately 100,000 tonnes of structural steelwork for the further expansion of their reprocessing facilities and chemical plants. The design of buildings to date has adopted a traditional approach assuming connections are either pinned or rigid. Recent research and papers on the alternative design strategies have been received with interest. However, potential cost savings will be limited because a need remains to provide for other hazard prevention requirements: i.e. other relevant 10000 year environmental loading, deflection effects on installed nuclear safety related plant and limitations to prevent accidental damage.

BNFL's design rules are largely based on American design codes for seismic resistant structures and as such permit connections of this type. However, their adoption would appear to be limited to less demanding structures such as service buildings and office blocks. The reason for this is that large chemical plant structures tend to require member capacity

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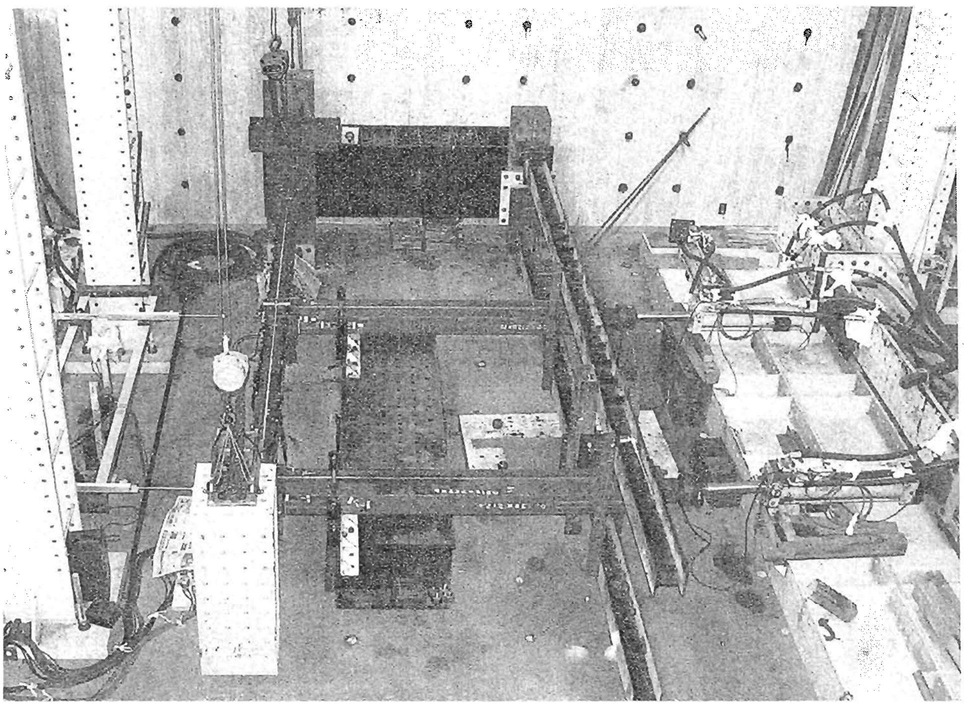


Left: Two storey semi-rigid frame tested using on-line computer control dynamic technique. Collaborative effort of Imperial College and the Institute of Industrial Science, Japan

SECED Meeting continued from page 7

connections as horizontal loading requirements are often as demanding as vertical loading requirements. Also lighter structures supporting chemical plant have deflection limits imposed on them and can usually utilise the stiffness and strength of heavy reinforced concrete shielding structures for lateral stability which are a common feature of nuclear installations.

To take full advantage of semi-rigid connections current codes require experimental data in support of the design. The cost of connection failure would be disproportionate to the cost of the components and potential saving. It would be essential for BNFL and its regulators to have confidence in the M - θ relationship adopted for analysis, the appropriate level of damping and determination of P – δ effects which may have implications for process plant and the design of columns in buildings of 3 or more stories high.

The areas of a typical nuclear power plant complex where semi-rigid steel frame design may be suitable are therefore limited and confined to such structures as service buildings and change rooms, and office and administration buildings. This represents current BNFL thinking, but is subject to review depending on the availability of test data to substantiate the reliability of semi-rigid construction under seismic loading.

Design Considerations

The advantages of semi-rigidity arise when accounting for the significant flexural strength which even nominally pinned connections possess, while at the same time seeking to avoid the considerable fabrication costs associated with traditional rigid joints.

Assuming that the joint moment rotation characteristics of semi-rigid joints may be defined at an early stage, it would be possible to perform frame dynamic analysis of the building structure, leading to results which suggest that for some structures the elastic forces computed can be safely carried by semi-rigid, and partial strength joints, without an undue deflection penalty. Whilst these results are promising, a number of technical issues require clarification before the semi-rigid design approach can be used with confidence.

Firstly we must be clear about the distinction between the term "semi-rigid", which strictly refers only to joint flexibility, and the term "partial strength". Usually, the semi-rigid type of joints under consideration will not sustain the full flexural strength of the members they connect. Secondly, we need to be clear about the meaning of the term "ductility". It is perfectly possible for joints to be ductile in the sense that they can distort significantly without fracture yet at the same time absorb little energy. Clearly the two joints can have identical ductilities but quite different in their energy absorbing capabilities and it is the latter requirement which is important in resisting earthquake action. Noting the need under UK assessments of nuclear safety-related structures for a demonstration against cliff edge effects it could be unwise to rely on structural forms which concentrate all the earthquake energy into joints which are weak links, especially if these are of low energy absorption capability (albeit highly ductile).

Another factor to be considered is the means of overcoming procedural features of the design, procurement and assessment process inherent in nuclear safety related designs.

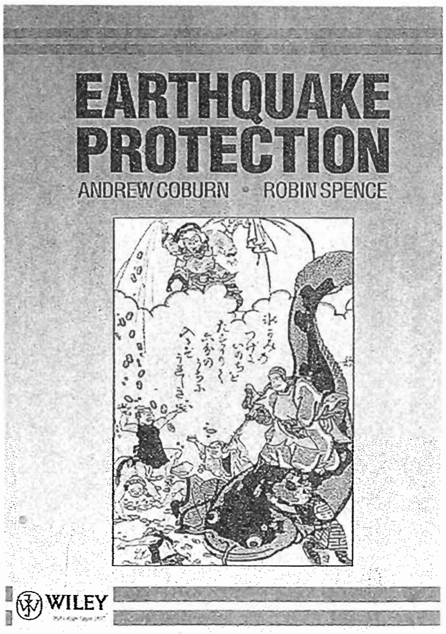
Two aspects stand out: firstly, normal practice is to allow the fabricator the choice of connection detailing methods, and secondly normal practice is to ensure that the dynamic analysis is verified by an assessment process in advance of detailed design and procurement. If therefore sophisticated analytical techniques are adopted allowing for joint flexibility, we must somehow pre-define the joint characteristics to the assessor and then specify them to the fabricator so imposing certain restrictions and potentially complicating the connection design procedure. Noting the real difficulties in defining even what "full strength" means, and the iterative nature of seismic design, specifying target joint flexibilities might be difficult. One route forward might be to carry out sensitivity studies on the structure allowing for potential variations in the joint rotational characteristics.

Closure

There is undoubtedly a surge of interest in the performance and design of semi-rigid steel frames, not only in recognition that the ideal two extremes; pinned and fixed, are unattainable, but also because of potential economies.

Our reliance on static concepts to dismiss the semi-rigid solution in seismic zones may lead to the wrong conclusion. Dynamic tests at Imperial College and elsewhere showed that in many cases the semi-rigid frame displaces less than its rigid (fully-welded) counterpart. This is attributed to period elongation and energy absorption in rotation. However, design practice is still reluctant to adopt this form of construction since our understanding is by-and-large incomplete and the required design-construction process is ill-defined. This should be an impetus, not a deterrent, for further analytical and experimental studies aimed at practical design recommendations for the connection, members and frames.

Book Review



Earthquake Protection
is reviewed by
Edmund Booth, Ove Arup & Partners

One of the fascinations of building in earthquake country is the contact it provides with a very wide range of different disciplines. The architect and structural engineer must of course understand something of the complex dynamic response of a building swaying under violent ground motion and of the way in which construction materials behave when subjected to large amplitude cyclic loading. However, not only the building is being shaken; the ground it sits on is also moving violently and the geotechnical engineer is needed, to advise for example on whether there is local amplification of the shaking (the 'bowl of jelly' effect seen most famously in Mexico City in 1985) or whether dramatic loss of soil strength could occur due to liquefaction. Other disciplines remote from construction are also involved. Earth scientists and geologists contribute to understanding and quantifying the seismic hazard, measured by the propensity of the site to suffer earthquakes and the risk of surface faulting. Since in many places, a proper establishment of the seismic hazard requires earthquake records dating back well before the modern instrumental era, historians are needed to research old documents for accounts of earthquakes in previous centuries. The processing of this mass of structural, geotechnical, seismological and historical data to produce usable results for the design of buildings requires complex statistical and mathematical skills.

Andrew Coburn and Robin Spence's book presents an overview of all of these aspects. It is a task that has been done a number of times before; the unusual feature of this book is that the authors also present another side of the problem, namely the human, political and sociological aspects. What sort of buildings are most lethal for their occupants when they collapse. What are the best organisational strategies for search and rescue after an earthquake? What sort of training and legislative processes are effective in ensuring an improvement of building practices? How can urban and rural planning account for and seek to minimise seismic risk? How can the impact of a major earthquake on the local economy be lessened? With a fixed budget, is it socially more useful to build a 100 bed hospital without consideration for earthquake resistance? Alternatively, should a stronger structure be provided, allowing money for only 90 beds, to produce a hospital that could survive an earthquake with a very low but still finite chance of occurring during the building's lifetime?

The authors discuss all these problems, with a firm emphasis on the fact that it is traditional structures, built without the aid of architects or engineers, that pose the greatest threat. They are well placed to discuss the issues. Both have specialised in various aspects of earthquake protection for a dozen or more years. Coburn belongs to that rare breed , a qualified architect with a post A-level knowledge of mathematics (less numerate readers need not worry, however; there are sections that will lose them, but most of the argument requires not much more than simple arithmetic). He has advised on reconstruction and planning in earthquake regions as far apart as Mexico City, Western Turkey and the Philippines with his colleagues at the Martin Centre, Cambridge, he has developed a new and very promising method of measuring earthquake damage intensity, which is presented in the book (though it is a pity that an appendix setting out some of the finer numerical details was not included). Spence is a chartered engineer with a particular interest in the seismic resistance and strengthening of traditional buildings, and also has extensive field experience. Together they have produced a readable and useful book which fills an important gap in the literature, full of practical examples from their professional experience. It will certainly be of interest to architects and structural engineers, but planners and politicians at both local and national level should also find much to inform them, and it would be nice to think that they will.

This is the UN's International Decade for Natural Disaster Reduction and earthquakes, of all natural disasters, are the most lethal; earthquake induced collapse of buildings have killed some half million people in the last two decades. Britain, one of the least seismic countries on earth, as always made much more than its fair share to the process of understanding and taming earthquakes and this book is a fitting UK contribution to the International Decade.

A shortened version of this review appeared recently in the Architects Journal.

PUBLISHER'S NOTE

Earthquake Engineering and Structural Dynamics

In order to make the journal more readily available to the earthquake engineering community the publishers have proposed to make the journal available to IAEE members at a reduced price. Members can write to Wiley at the address given below requesting a PERSONAL SUBSCRIPTION to the journal Earthquake Engineering and Structural Dynamics. For the 1993 volume 13 issues this will be US $95 (ninety five). This includes postage.

Applications to:

Ms Karen Gilbert,
John Wiley & Sons Ltd.
Journals Subscription Department,
Baffins Lane,
Chichester,
West Sussex PO 19 1UD,
Great Britain.

NOTABLE EARTHQUAKES JANUARY - MARCH 1993

Reported by British Geological Survey

YEAR	DAY	MON	LAT	LON	DEP KM	MAGNITUDE ML	MB	MS	LOCALITY
1993	7	JAN	55.350N	5.285W	11	1.7			ARRAN, STRATHCLYDE
			This was the largest in a swarm of ten small events in this area on 6 and 7 January						
1993	15	JAN	43.403N	143.259E	100		6.9	7.1	HOKKAIDO, JAPAN
			Two people were killed and 614 injured. Substantial damage in parts of Hokkaido and Honshu. Felt throughout most of Northern Japan.						
1993	27	JAN	32.025N	60.149E	33		4.9	4.2	NORTHERN IRAN
			Three people injured and 200 houses destroyed in the Nehbandan area.						
1993	5	FEB	53.169N	1.032W	1	1.1			EDWINSTOWE, NOTTS
			The largest of two events felt in the Edwinstowe area. The other 1.0 ML event occurred on 31 January. These were similar to other events which occur in this area and are believed to be related to coal mining activity.						
1993	6	FEB	56.129N	3.685W	2	1.1			CLACKMANNAN, CENTRAL
			One of two events felt in this area. The other event of 0.6ML occurred on 11 February. These were similar to other events which occur in this area and are believed to be related to coal mining activity.						
1993	11	Feb	58.962N	1.510E	9	3.8			NORTHERN NORTH SEA
			This event occurred near the Miller and Brae oilfields, but no felt reports were received.						
1993	6	Mar	57.494N	6.139E	15	3.3			EASTERN NORTH SEA
1993	6	Mar	10.929S	164.115E	33		6.0	7.1	SANTA CRUZ ISLANDS
1993	14	Mar	54.447N	1.001W	2	2.5			CLEVELAND HILLS
1993	18	Mar	38.346N	22.114E	52		5.6	5.3	GREECE
			Felt strongly throughout the Gulf of Corinth. Also felt at Athens.						
1993	26	Mar	37.221N	21.568E	10		5.2	5.1	SOUTHERN GREECE
			This is the largest of four events in this area on 26 March with magnitudes between 4.7 and 5.2MB. Two people were injured and damage occurred in the Amalias-Pirgos area. Felt throughout Southern Greece.						

Catalog of Significant Earthquakes 2150 B.C - 1991 A.D including Quantitative Casualties and Damage
by
Paula K Dunbar
Patricia A Lockridge
Lowell S Whiteside
September 1992
($46.00 including diskette (add $10 for foreign) from
National Geophysical Data Center, NOAA
Code E/GC4
Dept ORD 325 Broadway
Boulder, Co 80303-3328 .

This is the latest update to a catalog which lists historical earthquakes throughout the world that range in date from 2150 B.C to 1991 A.D. The events meet at least one of the following criteria : moderate damage (approx. $1 million or more) : ten or more deaths; magnitude 7.5 or greater; intensity X or greater (for events lacking magnitude).

For each event, the following are listed : date and time; epicenter; depth; magnitude; intensity; deaths; damage; tsunami, if generated; location; and references, when citations offer substantially different information. The diskette contains the catalog in ASC11 form.

Earthquakes are first listed in chronological order, then alphabetically by country or region. Customised maps illustrating magnitude, intensity, deaths, and damage from the significant earthquake database for a specified region are also available on request from the National Geophysical Data Center.

For more information, call the US National Geophysical Data Center at 303-497-6084 .

Structural Integrity

"Structural Integrity Assessment Primer (for Dynamically Loaded Structures)"

Published by the Dynamic Testing Agency (DTA) March 1993

Reviewed by John Maguire of Lloyd's Register.

Background

The Dynamic Testing Agency (DTA) is a collaborative club comprising industrial companies, research organisations and universities who are involved directly with dynamic testing and analysis. Its brief is to develop independent quality assurance standards and broad technical guidance, in the field of engineering testing, measurement and data analysis relating to structural dynamics.

The DTA has embarked on the production of a series of primers and handbooks, of which this is one of the first. The primers are aimed at giving an appreciation of the various facets to be regarded when considering dynamic testing, measurement and analysis, and are of interest to project managers and technical managers alike. They provide counsel on best practice for technical, managerial and quality assurance programmes.

Summary

This primer provides a general overview of how the numerous individual technical disciplines associated with dynamics and structural integrity may be combined to produce a unified methodology for performing a structural integrity assessment on dynamically loaded structures. Detailed methods and procedures relevant to individual technical disciplines are not presented in the primer. Instead, the reader is referred to the associated DTA handbooks where more specific information is available.

In such a wide ranging, multi-faceted subject, specific guidance based on a Code of Practice approach is unrealistic. Instead the primer provides a general *"Guidance Framework"* into which information relevant to the circumstances under consideration is used as input.

Observations

The author of this review was a member of the DTA Working Group which developed the primer. Other Working Group members came from Nuclear Electric, NEL, BEQE, BA, AEA, n-Code and SDRC.

Having used the primer, and associated handbook modules, on a number of projects the author has found the approach to be robust and reliable. The primer itself is laid out in a colour coded flow chart form which lends itself to easy use.

Availability

Having recently undergone a period of vigorous peer review the primer will now be published in March 1993, for DTA member trial usage and comment for a twelve month period. Final publication (incorporating feedback from members) is scheduled for Spring 1994.

For further details of the availability of this (and other) primers and DTA memberships, enquiries should be made to Neil Harwood (DTA Secretary) c/o NEL, East Kilbride, Glasgow G75 OQU Tel: 03552 72363.

Conference - CALL FOR PAPERS

THE SECOND INTERNATIONAL CONFERENCE ON "ENGINEERING INTEGRITY ASSESSMENT"

Glasgow - United Kingdom
Tuesday 10 to Thursday 12 May 1994

Details from:

Neil Harwood
Dynamic Testing Agency
Structures and Materials Centre
National Engineering Laboratory
East Kilbride,
Glasgow G75 OQU

Tel: 03552 72363
Fax: 03552 72047

WHAT'S ON

April - June 1993

14th-16th April 1993
Third International Symposium on Structural Crashworthiness and Failure
University of Liverpool

28th April 1993
SECED/BNES One Day Seminar
Uncertainty and Conservatism in Seismic Design for Nuclear Power Plants
Risley, Warrington
+ SECED AGM

26th May 1993
4th Mallet-Milne Lecture
Simplicity and Confidence in Seismic Design
Professor T Paulay
London

14th - 16th June 1993
Oxford Programme of Disaster Management and Development of Local Training
Disaster Management Centre
Oxford

14th - 16th June 1993
6th International Conference on Soil Dynamics and Earthquake Engineering
Bath

IDNDR Conference: Protecting Vulnerable Communities
at
The Royal Society, London
on
13th - 15th October 1993

addressing the following themes,
- vulnerability of communities
- forecasting and warning
- preparedness and protection
- lessons learned in recovery and reconstruction
- technology transfer and future opportunities

For information contact Rachel Coninx, IDNDR, Conference Office, Institution of Civil Engineers, Great George Street, London SW1P 3AA, United Kingdom.

Protecting Vulnerable Communities is supported by The Royal Society, The Royal Academy of Engineering and The Society for Earthquake and Civil Engineering Dynamics.

Forthcoming Events

7th - 9th July 1993
DTA & NAFEMS
International Conference on Structural Dynamic Modelling - Test, Analysis and Correlation
Cranfield, UK

11th - 14th July 1993
2nd International Conference on Emergency Planning and Disaster Management
Lancaster University, UK

15th - 20th August 1993
SMIRT 12
Stuttgart, Germany

23rd - 25th August 1993
International Post-SMIRT Conference
Seminar on Isolation, Energy Dissipation and Control of Vibrations of Structures
Isola di Capri, Italy

23rd - 27th August 1993
Tsunami '93
International Tsunami Symposium
Kyoto, Japan

2nd - 3rd September 1993
Joint SECED/AFPS Seminar
Dynamic Testing Facilities in the UK and France
Paris, France

22nd - 26th September 1993
Asian Disaster Preparedness Centre
7th International Seminar on Earthquake Prognosis, Hazard Assessment, Risk Evaluation, Loss Reduction and Earthquake Insurance
Bangkok, Thailand

29th September 1993
SECED/WES Meeting
Comparison of Wind and Earthquake Loading on Masts
Institution of Civil Engineers

13th - 14th October 1993
Safety & Reliability Society
Engineers and Risk Issues
Manchester

13th - 15th October 1993
IDNDR Conference
Natural Disasters: Protecting Vulnerable Communities
The Royal Society, London

27th October 1993
SECED Meeting
Computing for Structural Dynamics
Institution of Civil Engineers

1st December 1993
SECED/OES Meeting
Wave Dynamics
Institution of Civil Engineers

10th - 21st January 1994
IASPEI/Royal Society of New Zealand
27th General Assembly of the International Association of Seismology and Physics of the Earth's Interior (IASPEI)
Wellington, New Zealand

26th January 1994
SECED/AFPS Meeting
(title to be announced)
Institution of Civil Engineers

23rd February 1994
SECED Meeting
Blast Vulnerability of Building Structures
Institution of Civil Engineers

29th March 1994
SECED/EEFIT/EFTU Meeting
Earthquake Field Observations
Institution of Civil Engineers
+ EEFIT AGM

27th April 1994
SECED Meeting
Earthquake Engineering Design Case Studies
Institution of Civil Engineers
+ SECED AGM

23rd - 27th May 1994
IDNDR
World Conference on Natural Disaster Reduction
Yokohama, Japan

26th May 1994
SECED Meeting
Maximum Credible UK Earthquake
Institution of Civil Engineers

Contents

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).

SECED

SECED, The Society for Earthquake and Civil Engineering Dynamics is the British 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 Geological 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, United Kingdom.

Production by Allott & Lomax, Manchester.

ISSN 0967 - 859X

SECED NEWSLETTER

THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

April 1993, Volume 7, Number 2

SUPPLEMENT

A PEEP INTO THE FUTURE

In the framework of the *"Second Planning Meeting for Post Earthquake Investigations"* convened by the Council of Europe, the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the United States Geological Survey (USGS), it has been agreed that a pilot study of one year duration should be undertaken to determine if the efficiency and benefit of post-earthquake investigations can be improved by tighter cooperation, efficient pooling of existing resources, and dedicated use of communication networks. The project would be called the **Post Earthquake Evaluation Program (PEEP)**, and would be led by the Council of Europe, UNESCO, and USGS using existing resources, with other organizations being invited to participate in any way they choose using existing resources.

Post earthquake investigations encompass three types of studies:

* **Pilot**: the initial study conducted within the first few days to define the scope of subsequent studies.

* **Reconnaissance**: the studies initiated within the first few months to document what happened, to acquire perishable data, and to define the need for the scope of follow-up studies to capture the unique window of opportunity.

* **Follow-up**: the studies usually initiated several months after the event and lasting for several years or more to explain what happened and to share information and new lessons.

The primary objective of post-earthquake investigation is to study, in cooperation with local experts in the impacted communities, the cause and effect of earthquakes, immediately after their occurrence, for the purpose of improving scientific and practical knowledge in order to prepare for and mitigate the disaster consequences of a destructive earthquake. The participants agreed on the following points for the execution of **PEEP**.

Goal

Our primary goal is to minimize the cost and destructive impact of earthquakes on society. If **PEEP** is successful, the model will provide unprecedented world-wide increase and sharing of data and knowledge from post-earthquake investigations. This acquired knowledge will allow participating organizations to:

* improve basic knowledge on earthquake occurrence and the effects,

* improve earthquake hazard investigating and assessment capabilities,

* improve earthquake vulnerability evaluation, building performance assessment, and emergency response and preparedness plan,

* improve emergency response and recovery plans,

* develop earthquake mitigation and preparedness legislation,

* strengthen the enforcement of building codes.

Action Plan

The Council of Europe, UNESCO, USGS, and all of the cooperating organizations who choose to participate in **PEEP** will comprise an *Ad Hoc Expert Group*. It will undertake four actions:

i) Create a mechanism for sharing information

Members of the *Ad Hoc Expert Group* will seek to improve communication and interaction between themselves.

* The interaction between national and international groups working in post-earthquake environments will be facilitated by creating a dedicated "on-line information communication system" (OLICS).

* OLICS will have multi-user access capability for feeding and withdrawing information through a variety of media, e.g. e-Mail, FAX, telephone ("Voice Mail").

* 24-hour access throughout the world will be guaranteed.

* Practical implementation will be accomplished by e.g.: computer-network with mutual back-up capability (at least 1-2 components in the American and Europe-Mediterranean).

* Commercial communication systems with world-wide access and possibility of renting dedicated Mail-boxes (CompuServe, InterNet) will be assessed by conducting experiments.

Contents of Information -

Appropriate information which will vary with time after each earthquake facilitates the efficient planning and conducting of pilot, reconnaissance, and follow-up studies.

ii) Seek ways to strengthen interdisciplinary interfaces

The *Ad Hoc Expert Group* will seek ways to maximize cooperation among interested individuals/teams (earth scientists, engineers, rescue workers, social scientists, decision makers, etc.) at the various stages (pilot, reconnaissance, and follow-up) of post earthquake investigation. Participants (potential or actual) should be in contact with each other, get acquainted and work together to the fullest extent possible.

Establishing and strengthening the contact in all the interfaces (inside one discipline and interdisciplinary) should be fostered by all means.

Studies before the earthquake strikes:

* pool directories of potential investigators and expertise, and user/ practitioners of expected information,
* pool, share, exchange guidelines including those established for specific regions (e.g. Basilicata, Kalamata), and by specific groups (EERI, DHA-UNDRO, etc.).

Studies during & after the earthquake:

* inform participants preparing to go out to, or present in the field, of their activities to all others,
* identify ways different disciplines can complement each other in terms of time and use of resources,
* pool and disseminate post-earthquake reports: author lists, tables of contents, and possibly identification of complementarity,
* develop executive summaries that include the most salient findings and recommendations for all post-earthquake reports,
* let users know, upon request, what the expert community can follow-up (e.g.with briefings, specific recommendations, etc.).

iii) Develop a pool of resources for post-earthquake investigations

Each of the cooperating organizations have resources they can contribute to achieve the overall goal. For example, the *"Open Partial Agreement of the Council of Europe on the Prevention of, Protection Against, and Organization of Relief in the Event of Major Natural and Technical Disasters"*, through its network of specialized centers (6 of them being related to seismic problems), its European warning system, and its joint research programme under preparation, can contribute to the **PEEP** through its capacity for collecting and disseminating relevant information, and pooling efforts devoted by the skilled professional groups of the OPA member countries. UNESCO, with its *"Natural Hazards Program"* and collaborating wide scope interdisciplinary programs, and with the intergovernmental capacity, will provide the contact point of international cooperation. USGS, the Earthquake Engineering Research Institute and other professional organizations have experienced staff or members, portable equipment, and financial resources.

Pooling of equipment, know-how and logistic resources among different groups operating in the field will be encouraged to the maximum extent. Similarly, exchange and pooling of data and knowledge will be fostered.

iv) Develop post-earthquake workshops to foster mitigation, preparedness and recovery

The investigations of the causes and effects of earthquakes present the professional communities with opportunities to note areas of agreement in knowledge and practice, as well as possible areas where there may be disagreement and/or ambiguity which deserve further attention. This comparative work can be performed through formal gatherings which will bring together specialists to share insights and contemplate further follow-up studies in subjects which have particularly emerged from the pilot and reconnaissance work phases. The gatherings will take the form of thematic workshops focusing on a specific aspect of the problems created by the earthquake. If needed, wider multi-disciplinary seminars cutting across several themes may be convened. Recurrent and retrospective workshops should also be held over the years, sometimes on the occasion of anniversaries, in order to revisit the event and follow-up on unresolved or significant issues.

Technical Assistance to the Impacted Countries

Although all countries benefit from post-earthquake investigations, the most immediate benefit is always in the impacted countries. The foreign experts performing pilot, reconnaissance, follow-up studies will cooperate with the local experts who may have greatly increased demands because of the earthquake. They will also seek to contribute to the recovery process. Local experts will be invited to contribute to follow-up studies that are developed through **PEEP**.

Conclusions

Intermediate action and evaluation -

In order to achieve the goals and to conduct the actions described under the Action Plan, the present participating organizations in **PEEP** (UNESCO, USGS, and the Council of Europe) agreed on an experimental phase of implementation.

Over a period of one year it has been decided to take advantage of the existing structure: the European Warning System of the EUR-OPA Major Hazards Agreement of the Council of Europe, UNESCO and USGS will exchange their information concerning the post-earthquake investigation teams operating in the affected areas.

This experimental phase of implementation of **PEEP** will be reviewed next spring and will be evaluated at the end of the one-year phase by the *Ad Hoc Expert Group.*

Walter Hays
US Geological Survey

EARTHQUAKE ENGINEERING FIELD INVESTIGATION TEAM (EEFIT) FIELD REPORTS

The following field reports, prepared by the UK Earthquake Engineering Field Investigation Team (EEFIT) mission teams, are now available through the Institution of Structural Engineers:

The Erzincan, Turkey earthquake of 13 March 1992
The Manjil, Iran earthquake of 20 June 1990
The Luzon, Phillipines earthquake of 16 July 1990
The Newcastle, Australia earthquake of 28 December 1989
The San Salvador earthquake of 10 October 1986
The Mexican earthquake of 19 September 1985
The Chilean earthquake of 3 March 1985

EEFIT also plans to publish the following reports during 1993:

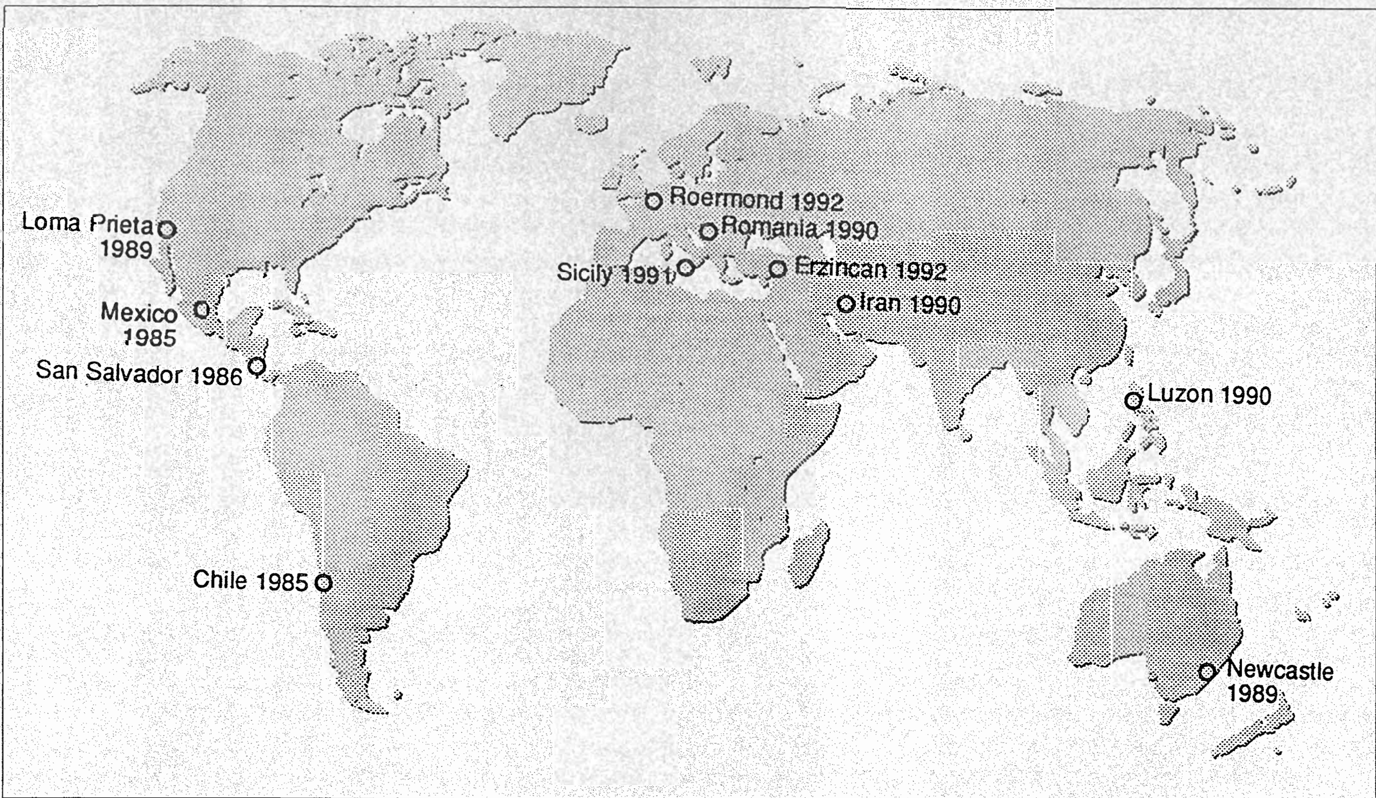
The Roermond, Holland earthquake of 1992
The Sicily, Italy earthquake of 1991
The Loma Prieta, San Francisco earthquake of 1989

All the reports consider:

- the mission methodology
- the earthquake affected region
- seismological aspects
- the types of damage, including its distribution and extent on both engineered & non-engineered structures
- the social and economic effects of the earthquake

and are illustrated with numerous photographs and figures depicting the effects of the earthquakes. **Slide sets** are also available for sale or hire for many of these earthquakes.

For further information contact Andy Loreans, the EEFIT Secretary, at the Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1X 8BH, United Kingdom.



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