SECED NEWSLETTER

THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

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SECED REPORTS FROM THE WORLD CONFERENCE

Approximately 1700 persons attended the Tenth World Conference on Earthquake Engineering, which was held in Madrid from 19 to 24 July 1992. There were about 1200 papers (selected from more than 2000 abstracts) bound in 10 volumes, with a post-conference volume planned, to include keynote lectures. There was a good British representation though well below expectation. More than 30% of the delegates came from Japan, followed by about 20% from the United States, with the rest of the world making the remaining 50%.

Some UK delegates and colleagues arrive at the World Conference

Several developments of interest occurred during the Conference; herewith a non-exhaustive summary.

- Professor Ambraseys was appointed Honorary Member of the International Association of Earthquake Engineering (IAEE).
- The South American countries, together with Mexico, Spain and Portugal, formed an earthquake engineering association of their own, to promote co-operation between member states.
- Three new states were admitted to the IAEE whilst one withdrew. Yugoslavia is no longer a member; Slovenia, Croatia and Macedonia are now represented as three independent national entities.
- A "World Seismic Safety Initiative" was launched with the aim of acting as a focal point for research within the remit of the IDNDR. The launch meeting was attended by Chris Browitt, representing SECED, and intermittently by myself.
- Tom Paulay was elected President, replacing Giuseppe Grandori, with Jose Grases as Vice-President.

On the issue of the venue of the next World Conference, there were finally bids from China, Mexico and the UK. SECED had prepared a brochure, slides and a video for the occasion. Support has been obtained from the Minister for the National Heritage, the Lord Mayor of London, the House of Lords, the ICE and the IStructE. Considerable thought was given to the organizational form, to avoid 1000 odd short presentations in favour of more lively discussions. Placing more emphasis on workshops, peer review sessions and posters was the theme chosen by SECED.

Voting took place on the last day of the Conference, after short presentations from the three national delegates. China went first and presented some slides from the Great Wall, the Forbidden City and other Chinese landmarks. The UK presentation touched upon the extensive opportunities in pre- and post-conference tours and entertainment, but focussed more on the format of the conference, the Barbican Centre (as a venue) and surrounding facilities. The Mexican presentation emphasized the high seismic hazard in Mexico, but had neither official support nor any ideas on organisation. Notwithstanding, Mexico won 19 votes, China came second with 8 votes and the UK won 7 votes, of the total 34 eligible national delegates. It is, however, rather amusing that the Mexican delegate declared in his presentation, prior to the vote, that they will adopt our proposal for the Conference format! Also, many delegates stated that although they did not vote for the UK, they hoped that our organisational framework will be adopted. The President, Tom Paulay, amongst many others, spoke very highly of our brochure; both presentation and content. This begs the question why did we lose the vote? The primary reason is that most delegates objected to having two conferences in a row

IDNDR News

UK UPDATE

Chris Browitt
British Geological Survey

Despite all of our knowledge and technology we have failed to limit the toll from natural disasters throughout the 1970's and 1980's. It has been estimated that 3 million lives were lost in that period, the number of disasters increased three-fold, the economic losses per decade almost doubled and the insured losses quadrupled. The number of victims from all other major disasters including fires, traffic, aviation, ships and the collapse of structures was dwarfed in the ratio of more than 10:1, by those from natural disasters. Among them earthquakes caused 60% of deaths and property damage in excess of $100 billion.

In the light of this massive human failure and in the knowledge that the technical capability existed but was not being widely applied to reversing these trends, the United Nations proclaimed the 1990's as the International Decade for National Disaster Reduction (IDNDR). The objective and goals were set as:

1. The objective of the International Decade for Natural Disaster Reduction is to reduce through concerted international action, especially in developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters such as earthquakes, windstorms, tsunamis, floods, landslides, volcanic eruptions, wildfires, grasshopper and locust infestations, drought and desertification and other calamities of natural origin.

2. The goals of the Decade are:

a) To improve the capacity of each country to mitigate the effects of natural disasters expeditiously and effectively, paying special attention to assisting developing countries in the assessment of disaster damage potential and in the establishment of early warning systems and disaster-resistant structures when and where needed;

b) To devise appropriate guidelines and strategies for applying existing scientific and technical knowledge, taking into account the cultural and economic diversity among nations;

c) To foster scientific and engineering endeavours aimed at closing critical gaps in knowledge in order to reduce loss of life and property;

d) To disseminate existing and new technical information related to measures for the assessment, prediction and mitigation of natural disasters;

e) To develop measures for the assessment, prediction, prevention and mitigation of natural disasters through programmes of technical assistance and technology transfer, demonstration projects, and education and training, tailored to specific disasters and locations, and to evaluate the effectiveness of those programmes.

Most of the 100 or so countries subscribing to the aims of the Decade have had a slow start in making any real progress but there are signs that momentum is increasing. It is now widely recognised that, with one quarter of the Decade already elapsed, the time for talking should now be finished and the time for action has arrived. In the USA, the Government have grasped this nettle and have just published an implementation plan with a focus on risk assessment, mitigation and preparedness, and access to prediction information. Bob Hamilton has returned from leading the IDNDR Secretariat in Geneva to chair a high level Federal Committee charged with getting things done. An inventory of

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held in Europe. Another reason was that the European vote was split whilst all Latin nations rallied solidly behind Mexico; this was demonstrated by the withdrawal of the Chillian bid in the last minute. To conclude, we lost the vote, but we won the respect of the delegates who recognised the effort and thought that went into our bid. The campaign puts us in a very strong position to bid for the next World Conference in the year 2000, or the European Conference in 1998, but this is a matter for the SECED Chairman and Committee of the day. Before I move to other issues, I would like to express my gratitude to the London Tourist Board Convention Centre, especially Mr. John Burt, who helped put together, at very short notice, our invitation to host the Conference. He also covered all the cost.

John Wiley had a stand where the Third Mallet-Milne Lecture, Reduction of Vibrations, was displayed. This was a very effective publicity occasion that no doubt enhanced SECED's reputation, so did Chris Browitt's timely circulation of the call for papers for the joint IDNDR/SECED Conference to be held next year. Also, free copies of Earthquake Engineering and Structural Dynamics (May edition) were distributed by Wiley, with two out of five papers from the UK.

On the quality of papers presented, this was highly non-uniform, as usual, varying between excellent and abysmal. It seemed that most people preferred the workshops and special theme sessions; this underlines SECED's proposals for future conferences. There was a special theme session Eurocode 8. Three main speakers commented on the code; Tom Paulay, Bob Park and Peter Gergeley. Whilst pointing out many shortcomings in EC8, especially the reinforced concrete chapter, they all, particularly Bob Park, praised the code and speculated that it will be adopted by other nations. Subsequently, Peter Fajfar announced that Slovenia has adopted all the Eurocodes, including EC8, to replace the national codes.

Amr Elnasai, Imperial College

disaster relief budgets in the US has shown that there is an existing budget of $3.5 billion but 96% is spent on post-disaster relief and only 4% on 'research'. The genuine research element may, in fact, be less than 1%. The policy is now to raise the US budget for pre-disaster measures to 10% of the $3.5 billion total.

Here, in the United Kingdom, the focal point of the IDNDR initiative is the ODA's Disaster Unit which, formerly, was almost entirely concerned with post-disaster relief but which is endeavouring to become more pro-active. The lack of high level British National Committee for the Decade has, arguably, held back UK efforts more than most. A Science and Technology Committee set up by the Royal Society and Royal Academy of Engineering two years ago has, however, been active in promoting the Decade. It held a Workshop in March 1992 attended by a broad spectrum of delegates including planners and the insurance industry. A one-day seminar on all forms of landslides has been organised for IDNDR day, 1992 (14 October) and a three-day conference (jointly sponsored with SECED) on Natural Disasters is scheduled to start on IDNDR day, 1993 (13 October).

The UK IDNDR STC Committee has agreed an organisational structure for the UK effort which will result in the establishment of a high-level National Committee, a Coordinating Committee and a series of Working groups; ideally, based on existing professional and learned societies. SECED has been cited as an organisation which might form a Working group to cover its field of interest. In the process of this re-structuring (by 1993), the present STC Committee will dissolve itself with some of its members expected to serve on the Coordinating Committee.

A full day special theme session on the Decade was held in Madrid during the IAEE's 10th World Conference with attendance by National Delegates, committee members and UNESCO/UNDRO representatives. The highlights were a report by John Tomblin on UNDRO initiatives and a draft report from a panel, chaired by Haresh Shah (Stanford), concerning an IAEE IDNDR initiative.

UNDRO have supported a number of disaster mitigation projects across a spread of countries, including the 16 bordering the Mediterranean to promote seismic risk reduction in that region and to make widely available the experience gained there. Of particular merit, has been a disaster mitigation programme in Colombia detailed in a report available from UNDRO. The country has suffered from serious events throughout its history, owing to its geographical position and topography, resulting in erosion, tsunamis, landslides, avalanches, floods, hurricanes, earthquakes and volcanic eruptions. The disaster potential has been exacerbated in recent years with an increasing population living in large modern cities in the highest risk areas. Becoming aware of the importance of developing adequate policies for risk mitigation and prevention following a series of disasters, the Colombian Government has been highly receptive to UNDRO and Canadian International Development Agency support in the project. Several disaster scenarios were examined in order to provide measures for reducing the risks. The result has been the consolidation, within Colombia, of the institutional organisation for disaster prevention and management. This has been achieved through "progressive convergence among technical-scientific work, political-administrative willingness and community acceptance, without which the most advanced hazard and risk evaluation cannot achieve its end".

UNDRO have detailed losses on a country-by-country basis as a proportion of GNP in order to obtain a measure of which have been worst affected. In the past 20 years, at least 19 countries have lost more than 2% of their GNP with 6 of them >5%. In money terms, the amounts are large, particularly in relation to expenditure on disaster mitigation measures.

In a reflection of the relative significance of different types of risk, UNDRO has devoted 40% of its time to earthquake problems over the past 2 years; the proportion being determined by external demand rather than internal bias.

National delegates in Madrid have endorsed an IAEE initiative described in a document entitled "A Time for Action: World Seismic Safety Initiative". Codenamed WSSI and pronounced either 'Wussy' or 'Wizzy' depending on which of the three IAEE-commissioned panel of authors was speaking, the goals are:-

1. Improve the dissemination of earthquake engineering information and knowledge so that engineers can design and construct earthquake-safe buildings.

2. Improve earthquake engineering practices for all types of construction by incorporating experience and research findings into recommended practices and procedures.

3. Advance knowledge through problem-focused earthquake engineering research.

The term "engineering" is used to include not only engineering but all other scientific and professional disciplines engaged in identifying, mitigating, responding to, and recovering from earthquakes.

It is a bold idea born of belief that, in this field, there is no suitable vehicle on the world stage through which new resources can be channelled coupled to the belief that there are new funds awaiting such a vehicle. It is intended that WSSI will be established by the IAEE as a 'not-for-profit' corporation governed by a Board of Directors appointed by the IAEE and answerable to the IAEE Executive Committee.

In the spirit of IDNDR, the World Seismic Safety Initiative is based on the principle that better construction practices, whether for engineered or traditional, non-engineered construction, saves lives and protects property. It accepts that much of the knowledge and research capability necessary to improve building practices exists today in scattered places around the world. The intention is to promote a greater degree of cooperation, world-wide, and to coordinate the knowledge and, particularly, its transfer. WSSI will endorse the activities and proposals of others thereby increasing their prospects of obtaining the necessary resources and it will encourage the initiatives of individual countries. Unusually, WSSI sets itself the target of increasing the worldwide resources for earthquake engineering research and technology transfer activities. If it succeeds in this fundamental aim, then it has a high probability of success.

WSSI proposes to achieve its objectives by providing world leadership in problem-focused projects with specific targets and work plans. Among those recommended for early implementation are:

1. Prepare scenarios for earthquake hazards and selected specific earthquakes that will characterise the ground motion, site failure, and damage likely at different locations.

2. Develop land use programs oriented to the reduction of seismic risk.

3. Provide technical expertise to regions addressing seismic safety issues, particularly following an earthquake when reconstruction practices and development planning are at issue.

4. Organise an international strike force of technical experts to quickly obtain perishable data at an earthquake site and develop a method by which it can be rapidly published world-wide.

5. Provide courses to train engineering teachers throughout the world in state-of-the-art engineering knowledge and construction techniques and in how to incorporate them into their curricula.

6. Disseminate knowledge about the ways to improve the seismic capacity of traditional, non-engineered dwelling construction.

7. Collect and distribute significant recorded motions of the ground and of buildings, without delay.

8. Develop education and training programs for skilled workers and unskilled builders of their own homes.

9. Provide the means for international cooperation among researchers and professionals on earthquake engineering issues.

10. Prepare an ongoing series of short (8-12 pages) engineering briefs, each one detailing one aspect of earthquake engineering practice or construction detailing and distribute them world-wide.

11. Develop engineering design practices for seismic retrofit of existing buildings suitable for incorporation in local and national building codes.

12. Initiate engineering and research projects on upgrading reinforced concrete buildings that are not earthquake-safe.

13. Develop and distribute a comprehensive library of engineering and earthquake engineering articles, research, and resources.

14. Overcome the language barrier by providing dictionaries, translations and technical resource documents for materials published in different languages.

The list is long and needs to be longer but George Housner, in closing the meeting, encouraged us not to be overwhelmed by the enormity of the task by recalling a saying which the Chinese have: "a journey of 1,000 miles starts with a single step".

Conference Call

SECED SPONSORS IDNDR CONFERENCE

The main thrust and spirit of IDNDR is to reduce the impact of natural hazards through the application of worldwide progress made in scientific and technological knowledge and, in particular, through the practical application and transfer of existing capability to high risk communities in developing countries. The aim must be to use advanced approaches to disaster reduction by developing techniques of implementation which are low-cost, broadly applicable and adaptable to the needs of all societies.

In this context, the **UK IDNDR Committee** extends a warm invitation to all scientists, engineers and practitioners working towards the reduction of the impact of Earthquakes, Floods, Volcanoes and Storms to participate in a Conference on International IDNDR day: 13th October 1993.

The conference title is
NATURAL DISASTERS: PROTECTING VULNERABLE COMMUNITIES
to be held at The Royal Society, London, 13-15 October 1993.

Conference sponsors are The Royal Society; The Royal Academy of Engineering; The Society of Earthquake and Civil Engineering Dynamics; British Nuclear Fuels plc.

The Conference theme is the protection of vulnerable communities and papers are invited on natural disaster reduction with emphasis on:

1. Vulnerability of communities

2. Preparation, protection and prediction before the event

3. Lessons to be learned (and implementation during recovery and reconstruction planning)

4. Opportunities for the future (low cost - high tech)

5. Technology and knowledge transfer

in the face of hazards posed by:

Earthquakes, Floods, Volcanoes and Storms.

Authors wishing to present papers are invited to submit two copies of typed abstracts of up to 500 words by 1st November 1992:

ICE Conference Office
Institution of Civil Engineers
Great George Street
Westminster
London SW1P 3AA

INTERNATIONAL POST EARTHQUAKE INVESTIGATIONS

In March 1992 the U.S. Geological Survey (USGS) and the United Nations Educational Science and Cultural Organization (UNESCO) convened a meeting in Paris, France to explore ways to improve international postearthquake investigations as an activity of the International Decade for Natural Disaster Reduction. The Council of Europe was a co-sponsor of the meeting which was attended by 25 participants representing organizations in the United States and Europe. The participants concluded that the quality and rate of learning from post earthquake investigations can be significantly accelerated through international co-operation .

Walter Hays, US Geological Survey, Reston, Virginia USA
and
Badaoui M. Roubhan, UNESCO, Paris, France

The following sections describe general procedures that should be incorporated into the planning process.

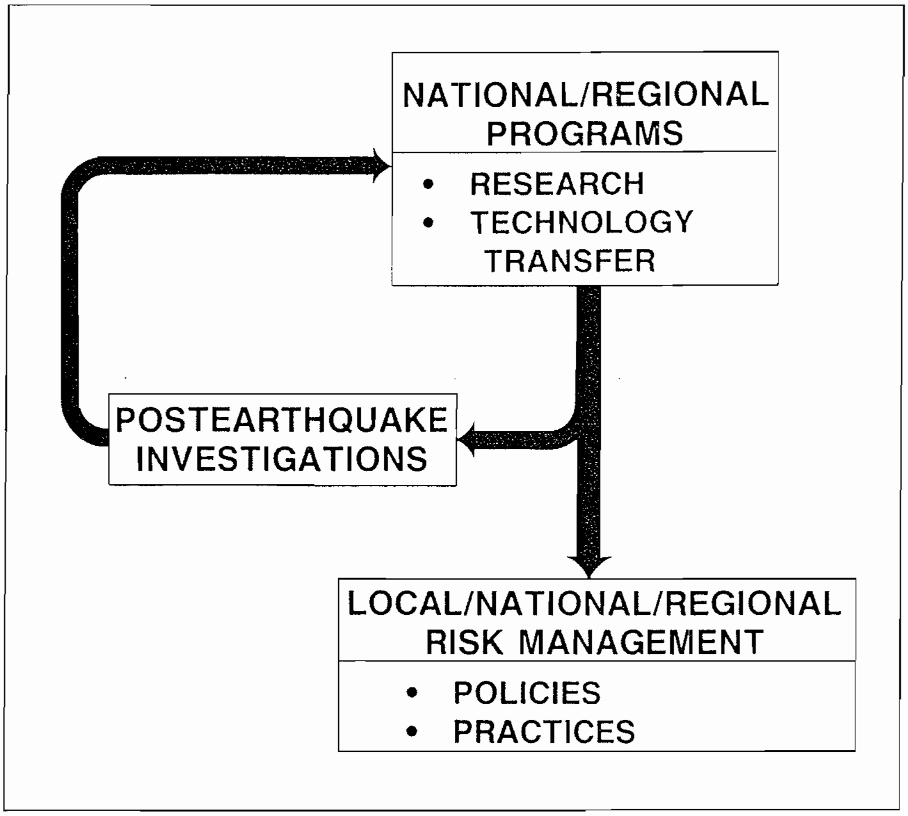
EARTHQUAKE PHENOMENA AND POSTEARTHQUAKE INVESTIGATIONS

A damaging earthquake creates three situations:

1) the urgent need for emergency response and recovery,
2) a "laboratory" for postearthquake investigations, and
3) an opportunity to improve earthquake casuality and seismic zonation studies.

An earthquake is one of nature's most devasting natural hazards. The sudden release of accumulated strain on a fault system, usually without warning, typically begins within the brittle upper crust or the ductile lower crust of the Earth. From the focus, the point in the Earth where the strain is initially released, mechanical energy is propagated in all directions in the form of seismic body (P and S) waves. When these elastic waves arrive at the surface of the Earth, longer period surface waves (Love and Rayleigh) are also generated. The body and surface waves act dynamically in space and time to excite into vibration the soil and rock and the structures (buildings, facilities, and lifeline systems e.g. bridges, buried pipelines, utility systems, tunnels, rapid transit) in an urban centre. The structures are excited into vibration individually as a function of their frequency response to the seismic waves. Structures having higher response frequencies, such as short buildings and short-stiff bridges, start virbrating first followed by the tall, buildings and long lifeline systems having lower response frequencies. At some locations, soil-structure resonance occurs when the soil and the structure vibrate at or very near the same frequency. The soil-structure resonance phenomenon can cause local intensification of ground shaking, leading to severe damage or collapse of inadequately designed and constructed structures.

The ground shaking can trigger liquefaction (a temporary loss of bearing strength at locations underlain by young, loosely compacted, water-saturated sand deposits) and landslides (falls, topples, slides, spreads, and flows of rock and/or soil induced on unstable slopes by the ground shaking). Some earthquakes will also generate surface fault rupture, where depending on the magnitude or amount of mechanical energy released at the focus and the depth of the initial rupture zone, the fault can propagate upward, and break the surface. Surface fault rupture, like liquefaction and landsliding, causes permanent displacements. Regional tectonic deformation (changes in elevation over a broad geographic region) is a characteristic of great earthquakes (i.e. those having magnitudes of 8 or



Left - Post earthquake investigations provide an opportunity to identify gaps in knowledge requiring research and to acquire new knowledge which can be transferred for the benefit of communities at risk from earthquakes.

greater). Tsunamis (long-period ocean waves generated by the sudden vertical displacement of a submarine earthquake) can generate flood waves that are very destructive at coastal locations far from and close to the earthquake source. Seiches, dam failures, and fires can also be induced by an earthquake. Aftershocks (smaller earthquakes, following the main shock) can last for several months to years. Individual aftershocks can repeat and worsen the physical effects described above, depending on their magnitude and proximity to the urban centre or site and the incipient damage state.

Four categories of multidisciplinary field work and reconnaissance studies are performed. Each involves teams of investigators who try to capture perishable data in the field as well as data for long-term indepth research. Together, they are designed to learn as much as possible from the "laboratory". They are:

1. **Earth Science Investigations -**

   Geologic Studies - These studies use over flights, satellite observations, geodetic measurements, and field mapping. They are essential for understanding ground shaking, crustal deformation, and ground failure; defining the regional seismo-tectonic setting; and mapping, assessing, and analyzing faulting phenomena, the response of soil deposits and bedrock, regional tectonic deformation, liquefaction, landslides, and flood-wave inundation.

   Seismological Studies - These studies are essential for characterizing and under-standing the main shock and aftershock sequence. Arrays of portable seismo-graphs are used to locate aftershocks, determine their spatial and temporal characteristics, define the rupture zone, relate the main shock to the long-term regional seismicity, and explain precursory geophysical phenomena, if any, before the main shock.

   Engineering Seismology Studies - These studies are portable strong motion instruments to acquire accelerograms and spectra. They are used to improve understanding of regional seismic wave attenuation and local ground response and to relate ground motion effects from both the aftershocks and the main shock to past observations. Strong motion accelerograms and spectra derived from them are the basic data generated by these studies.

2. **Engineering Investigations -**

   Engineering Studies - These studies are needed to ascertain the nature, cause, degree, and spatial distrubution of damage to a wide variety of structures (including: dwellings, low-, medium-, and high-rise buildings, industrial facilities, lifelines (i.e. those systems that transport people, distribute resources, and transmit information), essential facilities (e.g. schools, hospitals, emergency operations centres), and critical facilities (i.e. dams, nuclear power plants)). This information is used to develop and refine architectural, engineering, and land-use planning principles and practices. Damage ground-motion vulnerability relations are derived in order to refine or revise building and land use regulations and to improve siting, design, and construction criteria and professional practices. Technical assistance may also be provided to assess the safety of buildings (e.g. "red, yellow, and green" tags).

3. **Health Care Studies -**

   Morbidity and Mortality Studies - These studies are needed to provide a basis for correlating deaths and injuries with building type, geologic setting and geo-physical parameters, and engineering practices. These correlations contribute to improvements in search and rescue efforts and emergency health care.

4. **Social Science Studies -**

   Societal Response Studies - These studies are needed to determine how the populace reacted to earthquake hazards and risk information, to predictions and warnings, if any, and various advisory communications issued before, during, and after the earthquake. They show how communities made decisions about earthquake risk management in the past, adjust to the impacts, and take advantage of the window of opportunity that follows a major earthquake (i.e. a relatively short period of time during which a stricken community will sometimes act to adopt and enforce new seismic safety policies, often more stringent than those in place before the event).

BENEFITS OF POSTEARTHQUAKE INVESTIGATIONS

UNESCO and other international organizations can benefit from postearthquake investigations. The pre-earthquake environment is conceptually better for improving risk management policies and practices, however, the postearthquake environment is the one where the window of opportunity is open. An international team of experts could assist the stricken country by working with local professionals to integrate the results of post earthquake investigations with their experience and knowledge of the three systems:

1) solid earth,
2) built environment, and
3) social-economic-political.

During the postearthquake environment, the international team of experts will be answering questions that provide a complete picture of the earthquake and its impact in the context of the three systems described above. This picture can be used as a basis for improving the country's seismic zonation maps,policies, and practices. The basic questions posed by the damaging earthquake are:

* What was the magnitude of the earthquake?

* What was its location (i.e. the epicentre and hypocentre)?

* What fault system or seismogenic structure released the earthquake? How did it rupture (i.e. what type of fault : strike slip, reverse, normal)?

* Where are the locations of significant damage and the loss of function to structures? Lifeline systems? Essential facilities? Criticial facilities? Industrial facilities?

* What was the pattern of casualties?

* How likely are damaging aftershocks in the next hours, days, and weeks? New main shocks?

* How was the damage distrubuted spatially, i.e. the characteristics of the iso-seismal map?

* What levels of ground shaking occurred and how did they correlate with the damage distribution?

* Which buildings are
  a) safe for continued occupancy ("Green Tag"),
  b) possibly safe and require further investigation ("Yellow Tag"), or
  c) unsafe ("Red Tag")?

* What is the seismotectonic setting?

* Where are the locations of liquefaction and landslides and what damage did they cause?

* Which dams should have their water levels lowered?

* To what degree was the community prepared for the event and what facilitated or hindered preparedness and mitigation actions?

* How effective was the societal response before, during, and after the event?

* Where did soil-structure resonance occur?

* What actions might be taken to reduce loss of life and property?

CONCLUSIONS

In principle, countries throughout the world can benefit by sharing in international post earthquake investigations. Communities at risk from earthquakes will be able to obtain the best possible answers to the following questions and implement changes in their risk management policies and practices:

* What should be done now and with what priority to reduce casualties and to sustain community services or to restore them to normal after a damaging earthquake?

* What should be done to lessen the chance of a future earthquake disaster happening in the community?

* How much will these actions cost individually and collectively?

These answers can make communities throughout the world safer from earthquakes.

Research

JOINT UK/JAPAN TEST PROGRAMME

The earthquake engineering group at Imperial College has just completed an experimental programme on steel and composite frames, jointly with the Institute of Industrial Science (IIS), University of Tokyo. Six (almost) full scale two-storey frames were tested monotonically, cyclically and pseudo-dynamically. The frames were designed at Imperial College and tested in Chiba, Japan, using Professor Takanashi's on-line testing facility. Steel frames with semi-rigid connections were tested as well as composite steel/ concrete frames. A steel rigidly-connected frame was also tested for comparison.

Preliminary assessment of the results indicate that semi-rigid steel frames provide good seismic performance while offering considerable fabrication savings. With regard to the composite frame, the behaviour was, as expected, superior to the bare steel frame.

Full data processing and analytical studies are currently underway at Imperial. A joint ESEE/IIS report is imminent.

Professor Takanshi (IIS, Tokyo) and Dr Elnashai (IC, London) at the testing station in China, Japan

For further information about the project contact:

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WORKING AT THE MARGINS OF OUR DISCIPLINES TO ASSESS AND MANAGE THE RISKS FROM NATURAL HAZARDS

Walter W. Hays
U.S. Geological Survey
Reston, Virginia.

During the 1990's, a period designated by the United Nations as the International Decade for Natural Disaster Reduction (IDNDR), scientists, architects, engineers, urban planners, emergency managers, and medical service specialists will be working at the margins of their disciplines as they seek to reduce loss of life, human suffering, and economic loss from earthquakes, volcanic eruptions, severe storms (cyclones, typhoons, hurricanes, and tornadoes), floods, landslides, wildfires, tsunamis, and drought.

Planners, emergency managers, medical service specialists, architects, engineers, and scientists have important roles in reducing the risk from natural hazards in their community. Urban planners plan the way groups of engineered and non-engineered buildings will be combined to form streets and ultimately the urban center. Medical service specialists and emergency managers organize the human and material resources of the community for emergency response and recovery. Architects design individual buildings, focusing mainly on the building configuration, non-structural elements, and occupant safety. Engineers, architects, and scientists work together to ensure that new buildings will meet the requirements of the local building and land use regulations and withstand the physical effects of the hazards.

United Nations Resolution 44-236 established the IDNDR in December 1989. Targets have been set for each nation:

By the year 2000, each participating nation should have:

* national assessments of the risks from natural hazards, with these assessments being taken into account in development plans,

* mitigation plans at national and/or local levels, involving long-term prevention and preparedness and community awareness, and

* ready access to global, regional, national, and local warning systems and broad dissemination of warnings.

WORLDWIDE IMPACTS OF NATURAL HAZARDS

Throughout history, natural hazards have exacted a heavy toll of death and destruction, impacted the environment, and disrupted development in many nations. In the past two decades, at least 3 million were killed by the physical pnenomena accompanying floods, landslides, severe storms, wildfires, drought, earthquakes,tsunamis, and volcanic eruptions, and more than 1 billion suffered loss of property or adverse health effects (World Bank, 1990). At present, natural disasters take about 250,000 lives worldwide each year and cause about $47 billion in direct losses to capital stock and inventories. Indirect and secondary losses, which include: lost income, unemployment caused by loss of productive capacity, loss of natural resources, decreased economic growth, increased national indebtedness, inflation, balance of trade deficits, and welfare, are often 5 to 10 times greater than direct losses. Earthquakes, although they occur less frequently than floods, landslides, wildfires, severe storms, are one of the most destructive natural hazards as single events. Most of the world's earthquakes occur along the Circum-Pacific or "Ring of Fire". Earthquakes impact development. During the 20th century, more than 1.3 million people have died from the collapse of buildings due to earthquake ground shaking. The most notable earthquakes this century include: the 1906 San Francisco, California earthquake; the 1923 Kanto, Japan earthquake; the 1960 Agadir, Morocco earthquake; the 1964 Alaska earthquake; the 1976 Tangshan, China earthquake which killed at least 240,000; the 1980 El Asnam, Algeria and Campania-Basilicata, Italy earchquakes; the 1988 Spitak, Armenia (USSR) earthquake, the 1990 Iran and Philippines earthquakes; and the 1991 Costa Rica and India earthquakes. Unlike hurricanes, typhoons, cyclones, and riverine flooding, earthquakes cannot yet be reliably predicted in the time frame of days to weeks; therefore, preparedness and mitigation measures are the best ways to reduce loss of life and loss of function. Earthquakes have ruptured pipelines, oil storage tanks, and dams. They have triggered fires, and caused the shut down of nuclear power plants. Single events have caused direct and indirect economic losses of several tens of billions of dollars.

Past earthquakes have shown that damage patterns and failure modes are repeated over and over again because architects and engineers fail to correct the seven common mistakes which make buildings and lifelines systems vulnerable, namely:

1. Lack of consideration of resonance of soils and structures.

2. Siting on unstable soils.

3. Underestimation of lateral or torsional displacements.

4. Disregarding the need for regularity and symmetry of the building.

5. Hammering or pounding of adjacent buildings.

6. Design, arrangement, and fastening of non-structural elements.

7. Quality of the workmanship.

Floods, the most common of all natural

hazards, affect every nation one or more times every year. More than 70 percent of all deaths have occurred in India, Bangladesh, and China. The most lethal flood in recorded history was along the Hwang Ho (Yellow) River in China in 1887. An estimated 900,000 people were killed and 2 million were left homeless by it. In July 1991, floods ravaged China once again, this time along the Yangtze River. It killed at least 2,370 and caused direct economic losses of about $3 billion. Millions were stranded as hundreds of thousands of homes were destroyed. Factories were submerged and crops were washed away. Afterwards, one-fourth of the populace suffered from dysentery and/or malaria. Flood events like those have slowed development worldwide. They have disrupted water purification and sewage disposal systems, caused toxic waste sites to overflow, dislodged chemicals stored underground and above ground, and contributed to increased exposure to highly toxic biologic and chemical agents.

Landslides are also common in every nation. They are caused by meteorological or seismological events which trigger the mass movement of rock and soil on unstable slopes. They have destroyed and limited development. They have ruptured oil, gas, water and sewage pipelines causing the release of hazardous materials which not only affected water quality but also reduced the capability to fight fires. The worst landslides in terms of life loss occurred in Italy in 1916 and 1963, China in 1020, Japan in 1945, USSR in 1948 and 1990, Peru in 1962 and 1970, and the Philippine Islands in 1991. The 1970 Peruvian landslide buried the city of Yungay and part of the city of Ranrahirca, killing 18,000.

Hurricanes, cyclones, and typhoons are severe storms which form over tropical waters. Although their high wind velocities of up to 250 km/hour have caused great damage to buildings and destroyed billions of board feet of timber, flood waves from the storm surge have been the biggest killer. Nine out of ten fatalities are caused by drowning associated with storm surge as much as 80km long and 8m high. The greatest hurricane disaster in United States history occurred on September 8, 1900 in Galveston, Texas when a hurricane struck, killing more than 6,000 of the residents who were stranded on Galveston Island. Bangladesh, Hong Kong, Japan, India, the Philippines, and the Caribbean have also been hit hard in many past storms. In 1970, an estimated 500,000 were killed in Bangladesh as a tropical cyclone swept across the Bay of Bengal. In 1985, the death toll of 200,000, although high, was less than in 1970 due to the success of a newly instituted cyclone early warning system. In April 1991, several hundred thousand people in Bangladesh were saved again by the combination of the cyclone early warning system, community evacuation, and new cyclone shelters. In this storm, sustained surface wind velocities reached 220 km/hour and the storm surge reached a height of 8m. More than 1.5 million buildings were damaged and 750,000 houses were destroyed, leaving 10 million homeless. Economic development in Bangladesh has been severely impacted by these storms.

Tornadoes are the most lethal and violent of the severe storms. The worst tornadoes can have a width of more than 1km and travel 300km with a wind velocity of 500 km/hour. In the United States, as many as 700 tornadoes have struck in 1 year, most occurring between April and July. Buildings of unreinforced masonry or those having large numbers of glass or window areas are very vulnerable to the high wind velocities and low pressures generated in the storm. Most of the deaths and injuries and the environmental impact are caused by the flying debris (e.g. splinters, tar, glass, dirt, and manure).

Wildfires occur every year in many nations, usually along continually changing wilderness-urban interfaces. They can grow into large conflagrations which require an extensive investment of time and resources for suppression. They have damaged natural resources as well as urban areas. They leave an area more susceptible to floods and landslides. Drought impacted areas are especially vulnerable to wildfires ignited by lightning or other sources.

Drought is episodic, striking parts of all nations every several years. During long periods of drought, water quality has been adversely impacted. Development is slowed or stopped in drought-prone regions.

Tsunamis have impacted coastal communities of every nation located along the Pacific Rim and some nations in the Caribbean and Mediterranean seas. Destructive tsunamis flood waves struck Japan in 1933 and 1946 killing a total of 4,500 people. The tsunami generated in the 1960 Chile earthquake had flood waves of 20 to 25m which affected the coasts of all Pacific Rim countries.

About 50 of the world's 500 active volcanoes erupt each year. Like earthquakes, they are located mainly along the "Ring of Fire". Explosive volcanic eruptions have claimed more than 266,000 lives during the past 400 years, adversely impacted the environment, and disrupted development. One of the most catastrophic eruptions in history was Krakatoa, Indonesia in 1883, which caused the death of 36,000 people and caused global climate changes. Mt. Pelée in Martinique in 1902 which killed 30,000 , and Nevada del Ruiz in Colombia in 1985 which claimed 25,000 lives were also very devasting. In 1991, Mount Unzin in Japan, Hudson volcano in Chile, and Mount Pinatubo in the Philippines erupted, adding to the growing global death toll and adversely affecting air and water quality. Jet aircraft, especially vulnerable to volcanic ash, have been affected by recent eruptions. Lahars and debris flows, triggered by the rapid melting of snow and ice, or a glacier, are especially devasting, even at distances of 20 to 30 km. Cities such as Armero, Colombia in 1985 have been buried by lahars.

RISK ASSESSMENT

Risk assessments involve scientific, societal, and economic considerations. The main factors are:

a) the location of buildings, facilities, and lifeline systems within a community,

b) their exposure to the physical effects of a natural hazard, and

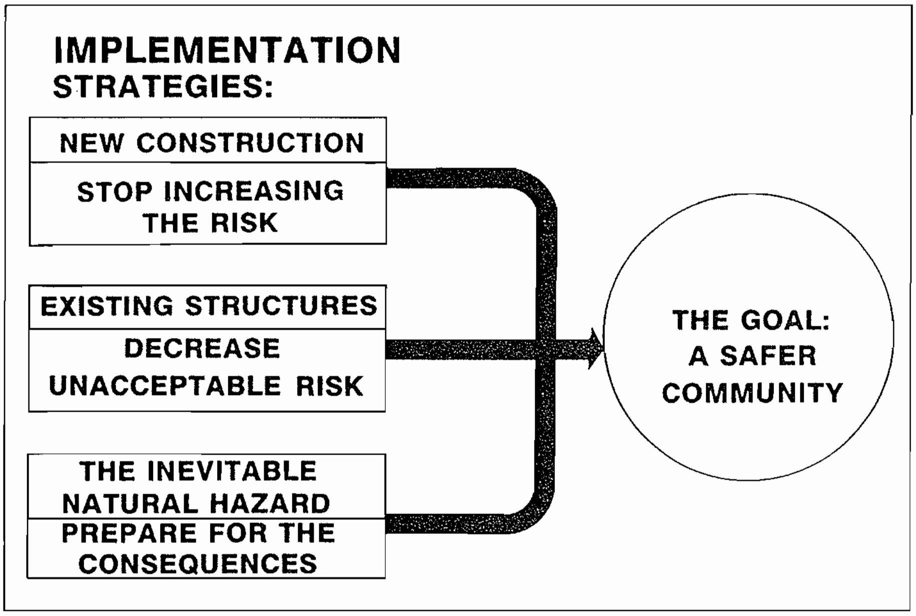
c) their vulnerability (i.e. potential loss

NOTABLE EARTHQUAKES APRIL - JUNE 1992

Reported by British Geological Survey

YEAR	DAY	MON	LAT	LON	DEP	MAGNITUDE			LOCALITY
					KM	ML	MB	MS	
1992	13	Apr	51.157N	5.815E	20	5.8	5.4	5.0	ROERMOND, NETHERLANDS
			One person died of a heart attack and 45 people were injured. Damage was reported at Heinsburg, Germany VIII MM and at Roermond, Netherlands. Felt strongly in many parts of north-west Germany, eastern Belgium and southern Holland. Also felt in north-east France and in parts of England.						
1992	23	Apr	33.943N	116.332W	10		5.8	6.3	SOUTHERN CALIFORNIA
			32 people were treated for minor injuries. Light to moderate damage occurred in the Joshua Tree and Yucca Valley area. Felt strongly in many parts of southern California and in parts of Nevada, Arizona and Mexico.						
1992	25	Apr	40.368N	124.316W	15		6.4	7.1	NORTHERN CALIFORNIA
			95 people were injured and considerable damage in south-west Humboldt County. Maximum intensity (VII MM) at Ferndale, Honeydew, Petrolia, Rio Deli and Scotia, and landslides and rockfalls occurred. Felt throughout much of northern California, in southern Oregon and at Reno, Nevada. A small tsunami was generated. Preliminary estimate of damage in this area is $66 million.						
1992	15	May	6.064S	147.588E	50		6.2	7.1	EASTERN NEW GUINEA
			Slight damage at Lae.						
1992	15	May	41.003N	72.409E	48		5.7	6.2	KYRGYZSTAN
			Three people killed. Over 500 homes damaged (VII MM) in the Osh area. Landslides reported.						
1992	17	May	7.260N	126.753E	33		6.2	7.1	PHILLIPINE ISLANDS
1992	17	May	7.169N	126.861E	33		6.4	7.5	PHILLIPINE ISLANDS
			Some minor damage at Tandag and Bislig.						
1992	18	May	56.763N	6.348E	10	3.4			NORTHERN NORTH SEA
1992	20	May	33.281n	71.299E	33		6.0	6.1	PAKISTAN
			36 people killed and over 100 injured in the Peshawar and Kohat districts. 400 houses were destroyed. Felt at Islamabad and Lahore and in the Srinager/Kashmir areas and in parts of northern India.						
1992	25	May	19.620N	77.820W	33		6.0	7.0	CUBA
			40 people injured and some damage reported in the Manzanillo and Niguero area. Damage also reported at Pilon and Yara						
1992	11	Jun	50.522N	8.949W	14	2.9			CELTIC SEA
1992	28	Jun	34.200N	116.500W	10		7.4		SOUTHERN CALIFORNIA
			One child was killed and over 200 people injured. Damage reported in the epicentral area. Felt over large areas of California, Arizona and Nevada.						
1992	28	Jun	34.000N	116.900W	10		6.5		SOUTHERN CALIFORNIA
			Felt over large areas of California, Arizona and Nevada.						

*Erratum: Peterborough earthquake 17th February 1992. The Longitude was 0.207**W**, not 0.207E as reported in the April edition of the Newsletter.*



Above - Schematic illustration of risk management options for coping with natural hazards.

in value) when subjected to these physical effects.

Risk is a statement of the economic losses, deaths and injuries, and loss of function expected when a specific physical effect (e.g. ground shaking or severe winds, triggered by a natural hazard) strikes a given region, local jurisdiction, site, or structure. When the spatial and temporal characteristics of the physical effects are fully integrated with a community's inventory of buildings, facilities, and lifeline systems, the risk to the community can be determined. Realistic mitigation measures can be adopted and enforced through siting, design, and construction practices.

The following questions are typical in risk assessments:

* What kinds of damage will the physical effects of a natural hazard cause to buildings, facilities, and lifeline systems that are at risk in a community?

* What have communities done in the past to control damage, deaths, injuries, economic loss, and loss of function from these effects?

* What societal, scientific, and technical actions will reduce the vulnerability of existing buildings and lifeline systems in each community to future events?

Loss estimates have been made in selected communities for scenario events of most natural hazards. These estimates have shown that two individual events, earth-quakes and hurricanes, are capable of causing catastrophic losses, potentially reaching 100 billion dollars or more in a single event (National Research Council, 1987). Such assessments have also exposed gaps in knowledge on spatial (e.g. urban to site-specific) and temporal (e.g. 10 to 100 years) scales. In spite of gaps in knowledge, such loss estimates are useful for a community. They can be used to: Identify especially hazardous geographic areas, groups of buildings, or lifelines; aid in the development of emergency response plans; evaluate overall economic impact on the Nation; formulate general strategies for reducing the risk from natural hazards (i.e. such as land use plans or building codes).

RISK MANAGEMENT

Risk management includes all of the options available to a community to cope with natural hazards. They encompass mitigation, preparedness, and emergency response measures (Figure 1). Mitigation refers to those actions that reduce the demands placed on the community by the natural hazard and/or that protect the community's capability. Preparedness refers to those actions that anticipate and reduce the demands and/or enhance and protect the community's capability. It includes prediction and warning. Emergency response refers to those actions that define the demands and/or manage and reallocate the community's capability. Natural disasters occur when increased or extraordinary demands are made on the community and/or there is inadequate capability or a decrease in the community's capability to cope with the increased demands.

WHAT'S ON

July - September 1992

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

7th - 10th September 1992
Institution of Mechanical Engineers
Conference on Vibrations of Rotating Machinery
Bath University

14th - 18th September 1992
Institute of Acoustics
Euronoise '92 - Co-operation in Noise Control
Imperial College, London

30th September 1992
SECED Meeting
Ground Borne Vibrations and Structural Damage - Presentation of New British Standards
Institution of Civil Engineers

16th September 1992
Offshore Engineering Society
Should Offshore Structures be designed for Earthquakes, and if so, how?
Institution of Civil Engineers

CONCLUSIONS

The IDNDR is a mandate as well as a unique opportunity for professionals throughout the world to work at the margins of their disciplines to make their communities safer from natural hazards.

FORTHCOMING EVENTS

5th - 9th October 1992
International Conference on
Risk Assessment
London

7th October 1992
Institution of Mechanical Engineers
Seismic and
Environmental Qualification
Institution of Mechanical Engineers, London

7th - 10th October 1992
Second International Conference on
Continental Earthquakes
Beijing, China

12th - 15th October 1992
Third International Disaster Congress
Havana, Cuba

14th October 1992
Institution of Mechanical Engineers
Meeting the Challenge of
European Safety Laws
IMechE, London

27th - 28th October 1992
Institution of Mechanical Engineers
Materials and Design Against Fire
IMechE, London

27th - 29th October 1992
SAVIAC
63rd Shock and Vibration Symposium
Las Cruces, New Mexico

5th November 1992
Joint SECED/WES Meeting
Hazard Assessment - Seismological
and Wind Comparisons
Institution of Civil Engineers

17th November 1992
Institution of Structural Engineers
Demolition and Explosives
Institution of Structural Engineers, London

25th November 1992
Joint SECED/AFPS Meeting
Presentation from the French
Association of Earthquake
Engineering
Institution of Civil Engineers

27th - 30th November 1992
IDNDR Chiba International
Conference Towards New Frontiers
against Natural Disasters
Chiba, Japan

15th - 17th December 1992
IDNDR International Symposium on
Earthquake Disaster Reduction
Technology
Tsukuba, Japan

27th January 1993
SECED Meeting
Seismic Resistance of Steel Frames
with Semi-Rigid Connections
Institution of Civil Engineers

24th February 1993
Joint SECED/OES Meeting
Analysis and Design of Offshore
Structures under Blast Loading
Institution of Civil Engineers

31st March 1993
Joint SECED/EEFIT/EFTU Meeting
EEFIT/EFTU Field Reports
Institution of Civil Engineers
+ EEFIT AGM

22nd - 23rd April 1993
Joint SECED/AFPS Seminar
Dynamic Testing Facilities in the UK
and France
Paris, France

28th April 1993
SECED Half Day Meeting
Conservatism in the Design of
Industrial Facilities
Risley, Warrington
+ SECED AGM

26th May 1993
5th Mallet-Milne Lecture
Professor T Paulay
London

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

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

SECED

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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).

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SECED NEWSLETTER

THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

July 1992, Vol. 6, No.3

MEMBERSHIP NOTES

STRUCTURAL DYNAMIC TESTING IN EARTHQUAKE ENGINEERING

A report of a SECED meeting on 'Dynamic Testing in Earthquake Engineering', 30 April 1992, at the Institution of Civil Engineers, London. Several presentations were delivered by a number of speakers from academic and industrial organisations.

The Role of Dynamic Testing in Earthquake Engineering

An overview of the role of dynamic testing in earthquake engineering was presented by Dr. Amr Elnashai (Imperial College). This included verification, calibration and development of analytical models, testing of new concepts and technologies, investigation of complex structures and qualification of mechanical and electrical equipment. He then discussed the structural engineer's involvement in dynamic testing. As an experimentalist he would be involved in studying the proposals and alternatives, design of test and peripherals, execution of the test, assessment of data and presentation of the results. On the other hand, as a client the engineer would make specific enquiries regarding the testing in addition to other tasks such as assessment of proposals, choice of appropriate schemes, monitoring of progress and budget, review of results and implementation of the findings.

Dr. Elnashai introduced the different testing methods such as controlled explosions, forced and free vibration, shake-table and pseudo-dynamic testing, static, monotonic and cyclic tests. The basic ingredients of the test is divided into the specimen, instrumentation, boundary conditions, loading conditions, data acquisition and control and data reduction and display. He also described the test models starting from field observations, structural monitoring, prototype testing and full scale models to scale models and tests on sub-assemblages, members and construction materials.

The choice of the testing method depends on the availability of testing equipment and a number of considerations such as the mass modelling and distribution, stiffness, damping and scale as well as the significance of strain-rate and soil-structure interaction effects.

On-Line Computer-Controlled Testing

Dr. Ahmed Elghazouli (Imperial College) described the on-line computer-controlled testing technique, also known as the pseudo-dynamic testing method. This method combines physical measurements and numerical analysis to simulate the

Below: Comparison of Dynamic Testing Methods

	Shake-table	Dynamic	Quasi-static	Pseudo-dynamic
Mass	table capacity	no mass needed	no mass needed	no mass needed
Specimen	both	lumped	lumped	lumped
Scale	limited	large	large	large
Load application	realistic	realistic	unrealistic	realistic
Stiffness	measured	measured	assumptions	measured
Testing time	real	real	static	pseudo-time
Strain-rate	included	included	not included	not included
Data acquisition	fast	fast	slow	slow
Soil-structure	not included	not included	not included	not included

dynamic behaviour of structural systems. The method uses similar equipment to quasi-static tests. However, it differs from conventional methods in that the displacement history imposed on a specimen is determined by an on-line computer. This displacement is based on the measured characteristics of the specimen and a specified excitation record. Displacements, imposed on the specimen quasi-statically, closely resemble those that would be developed if the specimen was tested dynamically. To achieve this, a test structure is first idealised as a discrete parameter system, the inertial and viscous damping characteristics of which are analytically prescribed. The displacement response of the structure to a predefined excitation is then evaluated by solving the governing equations of motion using reliable numerical integration algorithms. The computed displacement response is imposed on the specimen by hydraulic actuators. Based on the measured restoring force characteristics of the structure from the previous steps and the prescribed inertial and damping values, the displacement for the next time increment is calculated.

The pseudo-dynamic method, therefore, utilises the same numerical approaches used in the nonlinear dynamic analysis, except that the nonlinear stiffness is based on direct experimental feedback rather than on idealised mathematical models. It has the potential for combining the versatility and economy of quasi-static testing with the realism of shake-table testing. Dr. Elghazouli described the facility developed at Imperial College. The accuracy and realiability of the system was demonstrated through several verification tests in both the elastic and inelastic ranges. He also presented methods to evaluate and assess the experimental errors in the testing system. This facility has been extensively used at Imperial College in a recently completed SERC-funded project dealing with the behaviour of composite steel/concrete members under earthquake loading. The system will also be used in testing full scale two-storey frames with semi-rigid connections.

Shaketable Testing

Dr. Colin Taylor (Bristol University) focussed attention on quality assurance and its applications in not only testing, but research in general. He highlighted some interesting applications that have been undertaken at Bristol in shake-table testing as well as advanced monitoring and image processing techniques.

Dr. Joe Fairbairn (National Engineering Laboratories, NEL) described the dynamic testing facilities at NEL. The Structures Centre at NEL has one of the most extensive and comprehensively equipped structural testing laboratories in the UK and undertakes a wide variety of testing for a broad range of industries. Much of the testing requires the simulation in laboratory of dynamic in-service loadings on full-scale structures and equipment, and involves the design and construction of special purpose rigs for testing one-off prototypes. A considerable laboratory and equipment infrastructure exists to enable this. The main structures laboratory is 60m long and 16m wide with a height of 15m and has a strong floor extending over most of the area. Power for servo-hydraulic loading systems is provided from a central pump installation of 2MW capacity providing a flow of 45001/min at 210 Bar. The Centre has two multi-axis shake-tables and two single axis; one vertical and one horizontal. In terms of payload capacity, the Centre has the biggest facility in Europe. This is a five degrees of freedom shake-table with the yaw rotation constrained.

The first shake-table seismic qualification tests at NEL were carried out almost exactly ten years ago and the 200th seismic testing project was completed recently. While most of the testing has been related to electrical and mechanical equipment a number of very large structures have been tested at NEL. In the main these projects have involved the use of dynamic testing to develop and validate computer models and modelling techniques which is one of the most powerful uses of full-scale dynamic testing.

The NEL facility contributed to the qualification of the core of the advanced gas-cooled reactor for Hesham and Torness programmes. NNC validated the design of the core by a major mathematical modelling and computer analysis program. Shake-table testing was carried out at NEL to provide experimental data for development and confirmation of the analytical procedures. Vibration tests were carried out on a number of modules of full-scale graphite core bricks representing various configurations in the core. Each of the test structures weighed around 20 tonnes.

More recently the Centre undertook its largest shaker table project to date. This involved 3-axis earthquake simulation testing of a full-scale stack of nuclear waste stillage boxes. The test structure consisted of a nine high free standing stack of boxes with a height of 12 metres and a mass of 60 tonnes. The project was completed very successfully with both the test structure and the test facility coming through with flying colours.

Seismic Qualification by Testing

John Colloff (British Nuclear Fuels Ltd) briefly described the paper that he presented at the ASME P.V.P. Conference in New Orleans in June on Seismic Qualification of Standby Generators.

The first part of the paper described the problems experienced in seismically qualifying a gas turbine generator that was too heavy for the NEL shake-table at East Kilbride. Similar sets were from a world-wide search and their performance during seismic events analysed. From an overlay of the response spectra of the various events the machines had survived, and a combination of selected calculations and low level vibration testing, a case for seismic qualification of the candidate machine had not been completed.

The second part of the paper describes an economical and simple test developed to seismically qualify existing equipment in a standby diesel generator installation. The equipment was mounted on brick walls that were on ground bearing foundations. For UK seismically, even the maximum enhancement possible would not give loadings exceeding 100%g (1.0g). This was applied by tipping the items onto their four vertical faces, thus qualifying the item. To confirm that this procedure covered the full seismic range of enhancing frequencies Mr. Colloff ended by showing the response spectra that had been recorded of the world's only seismically qualified cardboard box when it was taken through this procedure.

Testing and the Design Process

Edmund Booth (Ove Arup & Partners) discussed the use of dynamic testing in engineering consultancies. He described a recent project conducted jointly by Arup and Bristol University. The chief aim of the project was validation of non-linear dynamic software against test results generated on the Bristol shaking table and elsewhere. A subsidiary but important aim, relevant to this discussion, was an examination of the possible use of models tested on shaking tables as part of the design process, in the same way as wind tunnel tests are routinely used for major buildings or impact tests for designing crashworthiness of cars and transportation packages.

As part of the joint Arup/Bristol project, a 15th scale model of a ten storey building was built and tested on the Bristol table. The model building was loosely based on an office block recently completed in Tokyo. From design to testing took the best part of a year. Even so, several important details in the model had to be substantially simplified because of the difficulties of modelling at small scale; the simplified details included the floor to beam connection details and the shear links in the eccentrically braced steel frames used as part of the lateral road resisting system.

It was concluded that the time scales involved in the model testing of a building were likely to be too long to be of practical use on normal projects, even allowing for the reduced time which would apply with the benefit of experience and the extra push and resources available for a fee-earning project. Since the computer generated results predicted the experimental ones very satisfactorily, even in the highly non-linear range no great need for dynamic testing of small scale models of conventional structures was envisaged. However, static cyclic tests of at or near full scale (for example unconventional beam column joints not covered by current codes) was seen as a more likely use for physical testing during design of seismically loaded structures.

EARTHQUAKE MODELLING FOR GEOTECHNICAL APPLICATIONS

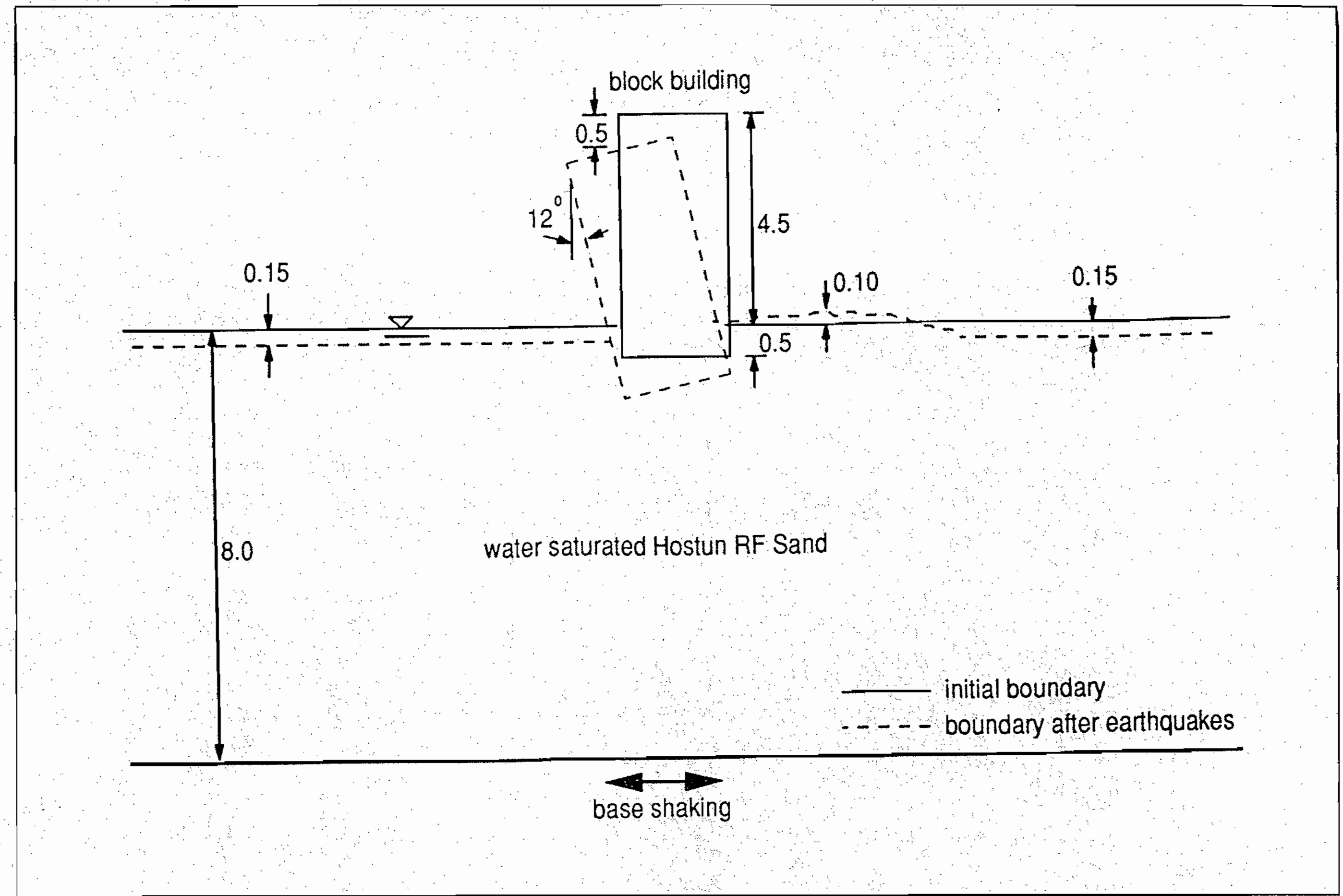
A SECED meeting report on Earthquake Modelling for Geotechnical Applications held jointly with the ICE East Anglian Local Association on 20th May in Cambridge. Participants included researchers, engineers and research students. The meeting discussed examples from the field of earthquake related geotechnical failures and the state-of-the-art physical and computational models that are being developed at Cambridge, Bristol and Glasgow Universities to improve our understanding of geotechnical phenomena induced by earthquake loading.

By way of introduction Dr. Scott Steedman, Director of the Geotechnics Division of BEQE, showed examples of earthquake damage in the field and stated the importance of research in understanding the seismic response of earth structures. The lack of high quality field data has made it impractical in the past to check the validity of design methods against historical events and hence physical modelling approaches have become increasingly significant. He then discussed the purpose, background and objectives of the current SERC sponsored collaborative research programme addressing "The application of dynamic geotechnical modelling to design" which involves the Universities of Cambridge, Bristol, Glasgow and Nottingham working together to develop a coherent approach to the question of validation.

Physical Testing

Dr. Colin Taylor Bristol University presented some initial results from the design of a new shear stack for the SERC Shaking Table and from a study of the seismic response of block buildings. Data of shaking table tests showed the design of the shear stack is satisfactory. Progress has been achieved in understanding soil behaviour under seismic loading.

Centrifuge modelling has the advantage of being able to create realistic stress conditions in a model. Dr. Zeng reported the design criteria and experimental results of an equivalent-shear-beam (ESB) model container at Cambridge. He described how in the field most events take place in soil layers of large lateral extent. To replicate the behaviour of a prototype structure in the field the artificial boundaries imposed by a model containment should therefore be able to mirror the prototype stress and strain conditions. The use of the ESB model container satisfies these requirements. Centrifuge tests have been carried out on block buildings on a saturated sand bed in the ESB model container. Following a sequence of earthquakes inflight the model structure failed, showing large vertical settlements and rotation. A cross-sectional view of the model before and after the test is shown in the figure overleaf. This failure mechanism is very similar to examples of tilted structures from the field and the tests show how large amounts of detailed information concerning the seismic



Above: Failure mode of a block building replicated in centrifuge test.

response of, in this case, block buildings can be acquired for use in validating design calculations or numerical models.

Numerical Modelling

At Glasgow University numerical predictions of the block building response were made using the SWANDYNE Code in advance of the actual testing. Dr. Chan discussed the background of numerical modelling and the progress that has been achieved at Glasgow University. Different types of soil model were used. It has been found that perfect elasticity is rather successful in matching the observed response of a sand to low level earthquakes but the response to higher level shaking remains difficult to predict.

In conclusion Professor Muir Wood of Glasgow University emphasised the importance of the collaboration between researchers use different techniques. He pointed out that the project has been extremely valuable in bringing together teams of numerical and physical modellers; increasing the awareness within each team of the problems and practices of others. There has been substantial benefit to the civil engineering community by co-ordinating the research effort and tackling the same generic problem by numerical modelling and physical modelling both at high gravities and at 1g.

X Zeng, R S Steedman

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