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NEWSLETTER

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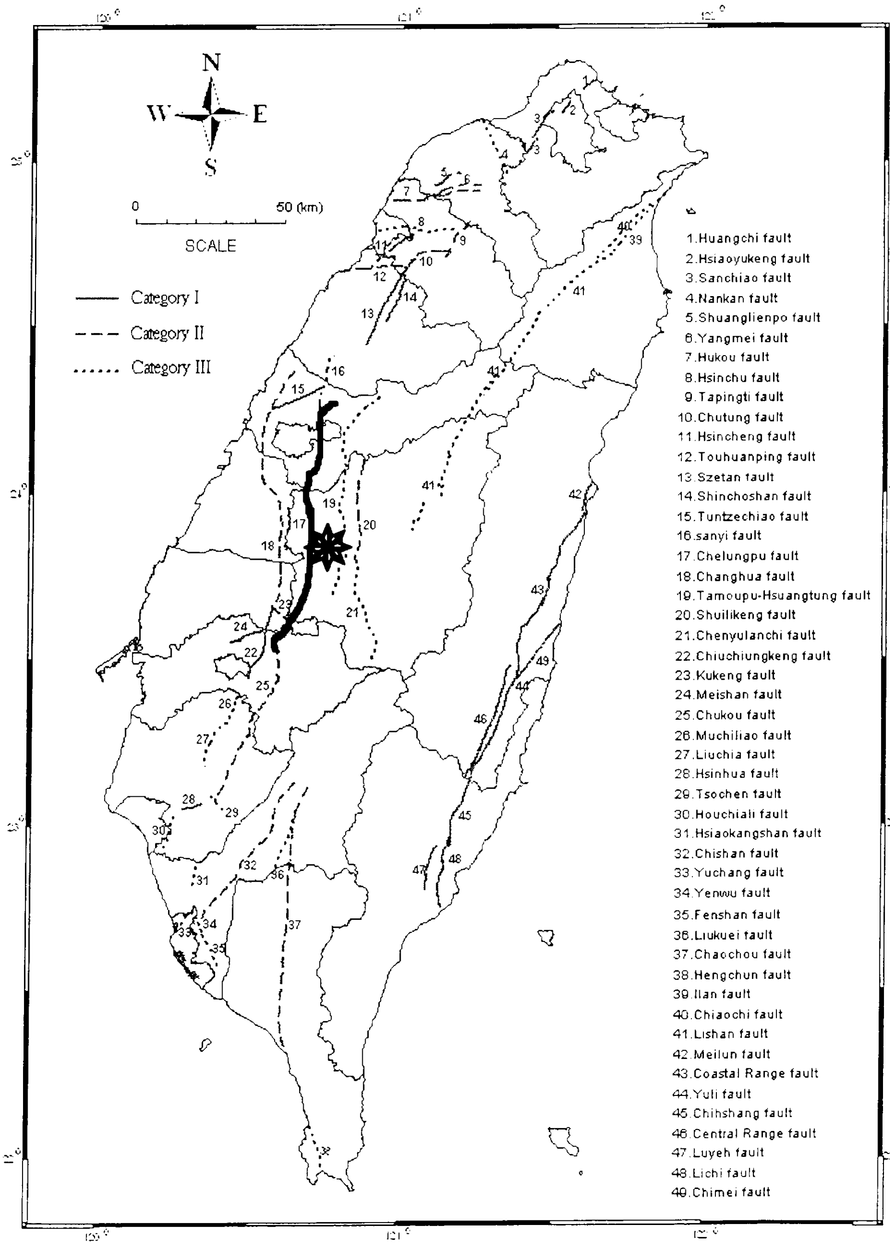
The Chi-Chi, Taiwan Earthquake of 21 September 1999

The Earthquake Engineering Field Investigation Team sent a team of ten investigators to examine the effects of the Chi Chi, Taiwan earthquake of 21 September 1999. The team spent just over a week in the damage zone in early October.

The magnitude 7.4 earthquake hit central Taiwan (Fig. 1) in the early hours of the morning, leaving over 2000 people dead, many thousands more injured, and over 100,000 homeless. By daybreak, the awesome power of plate tectonics became apparent. A massive thrust fault had broken through to the surface over a length of over 50 km. At the northern end of the fault, the ground had risen 9 m and moved westwards about 6 m.

Such surface rupturing of a thrust fault is rare. It is even rarer for the fault to cross a dam. The Shikhang dam, about 20 km northeast of the city of Taichung suffered this fate with amazing consequences. The fault clipped the northern end of dam, leaving it about 5m shorter, and its southern section about 9m higher than its northern section (Fig. 2). The northern gravity dam section was driven into the valley side by 1.5m. The effect of the ground movement can be appreciated best by lining up the hinge pins of the radial gates, which were all at the same level before the quake.

Yet, surprisingly, the dam breach did not lead to a catastrophic downstream flood. Instead the reservoir seems to have discharged relatively slowly through the damaged crest gates, and the flood was no greater than occurs following a typhoon. A possible

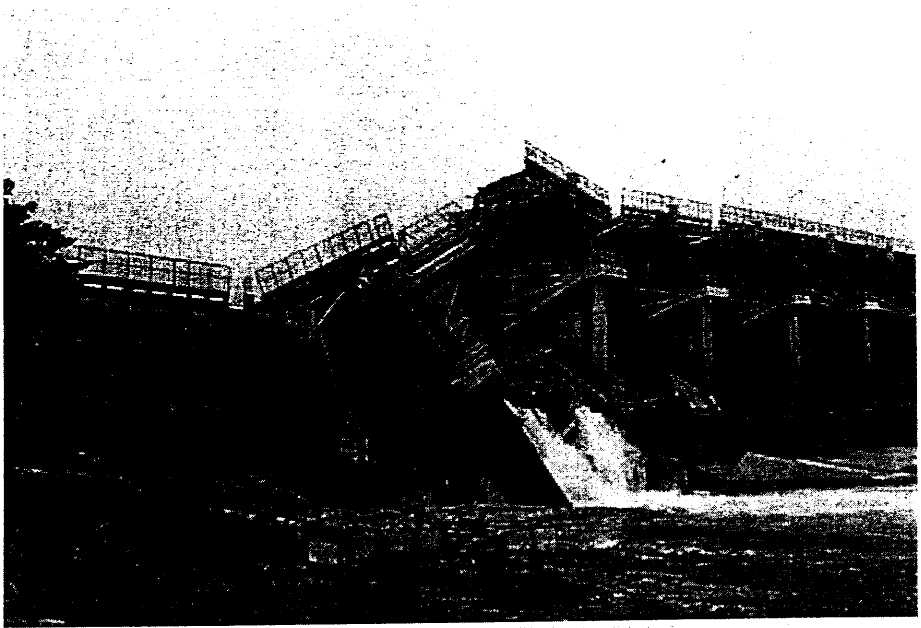


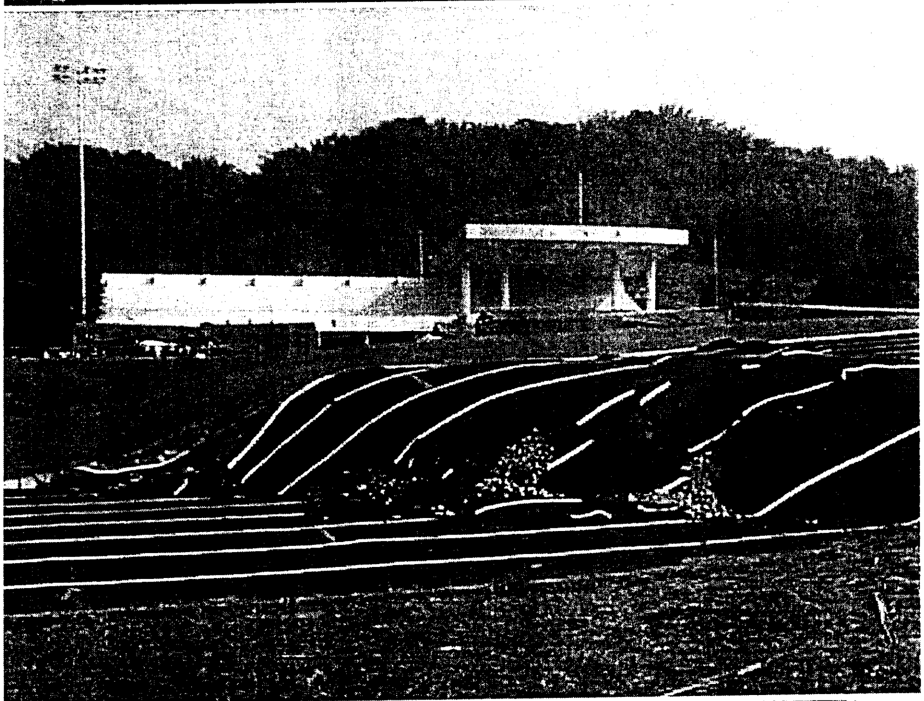
Active Faults in Taiwan
(Data source: Prof C T Lee, NCU)

Figure 1 Chelumgpu Fault Break and Epicentre at Chi-Chi

Figures: (Top to Bottom)

2) Thrust fault break through Shihkhang dam. Right hand side of dam has risen ~9m relative to left hand side. Dam has shortened by about 6m. Left hand gravity dam section driven into hillside by about 1.5m.
3) Thrust fault break through running track at Wufeng. About 3m vertical and horizontal throw. Note lack of damage to grandstand.
4) Thrust fault break through school buildings at Wufeng.





explanation is that the reservoir actually drained *upstream* initially, as the reservoir floor rose 10m relative to the upstream river bed.

A puzzle was the apparent lack of damage to structures adjacent to the fault. In one case, the fault had cut through a school running track with about a 3m throw. But the grandstand, less than 50m away, was undamaged (Fig. 3). Adjacent school buildings were not so lucky. The fault passed right through some of them with devastating effect (Fig. 4). Luckily the earthquake did not occur during the school day. However, other school blocks within 50m of the break were still serviceable, and the school had reopened by the time the EEFIT team visited it.

On the whole, damage was patchily distributed over a wide area. It seems that the large fault movements occurred slowly over a period of perhaps 20-30 seconds, with relatively low intensity shaking occurring close to the fault break. This would explain the lack of damage in these locations. Further away from the fault, ground shaking was more typical of a magnitude 7.4 event, and greater damage was apparent.

Inevitably, many building failures were due to classical design and construction flaws, with soft storey collapses being common (Fig. 5). Coupled with many soft storey collapses was poor detailing of reinforced concrete columns (Fig. 6). These observations demonstrate once again the need for better education of engineers and builders in the basic principles of earthquake design and construction.

Figure 5 Typical Soft-storey collapse

Figure 6 Failure of badly detailed RC columns

Bridges also suffered badly, often being bisected by the fault rupture. In one case (Fig. 7), the driver of a van found himself airborne. Debris clearly marked the point of impact of his van near the top of the fallen span in front of him. The driver survived.

The response of the Taiwanese authorities to the earthquake was very impressive. When the EEFIT team arrived, all the major highways had reopened, many buildings had been demolished, and life for the majority was almost back to normal. Ingenious solutions to bridge repairs included the use of a stack of shipping containers to create a temporary access ramp to the intact section of a major bridge, which was carrying traffic as normal.

The willingness of the Taiwanese engineers and authorities to share information and discuss their experiences contrasted with the reluctance shown by their counterparts in other countries after similar events. This gives real hope that the lessons from this earthquake will be learned and that actions will be implemented to mitigate the effects of future damaging earthquakes in this most interesting of countries. The earthquake will yield the best ever instrumental data set, with several hundred strong motion records being made available in early 2000 as well as extensive GPS measurements of surface displacements.

A full EEFIT report is scheduled for publication May 2000. Further details may be obtained from the mission leader,

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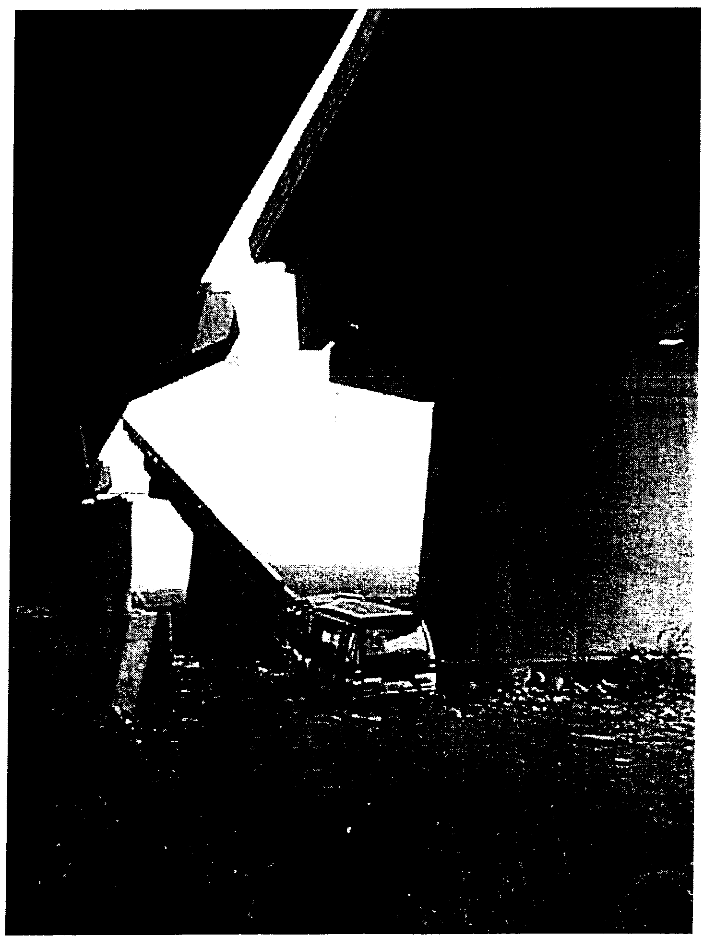


Figure 7 Failure of bridge that straddled the fault line

MEETING REPORT:

STRONG MOTION RECORDS FOR ANALYSIS AND DESIGN

Held on Wednesday 24 November 1999

A virtual debate on the issues raised by this meeting will be hosted on the SECED website until 1st April 2000; any significant results will be published in a subsequent Newsletter. For details, see the end of this article.

Designers of earthquake resistant structures are increasingly looking to use time history rather than response spectrum based methods. Whether it is to investigate local ductility demands in ductile structures, or to evaluate the response of base isolated structures, or to carry out complex soil-structure interaction evaluations, time-stepping analysis is likely to be needed and a reliable and realistic time history is required. However, there is a fundamental problem; design codes are based around response spectra which are quite unlike those of the motions recorded in any real earthquake. There is a good reason for this; design spectra usually represent the smoothed envelope of a range of possible events which might affect a certain site, and it is one of the strengths of response spectrum analysis that it can, in one shot, make a reasonable stab at the maximum response of lightly damped, linear elastic systems to this range of possibilities. But when other conditions apply - the presence of important non-linearities, or discrete dampers for example - the usefulness of response spectrum analysis begins to break down, and direct time history based methods are required. The question of how to select time histories that are reliable for the purpose required, while still satisfying code requirements without undue conservatism, is therefore an important, timely but complex one.

The extent of interest in such issues was confirmed by the large turnout of about 70 people to hear Drs Bommer, Morris and Aspinall talk about their approaches to the problem; these approaches concerned (respectively) time histories obtained from real earthquakes, those generated artificially to be compatible with specified design spectra or those created from accelerograms of small earthquakes using Green's functions.

Julian Bommer, of Imperial College London, covered the real time histories. His presentation was based on a recent EPSRC funded project, one of the aims of which was to test the sufficiency of the existing database of ground motions held by Imperial, particularly for the purposes of structural design. After eliminating records with weak motions and uncertain parameters, recordings for about 1600 events recorded up to 1995 are available from the database, usually in three orthogonal directions. Motions selected for design purposes must be suitable in terms of amplitude, frequency content and duration; the latter is particularly important for non-linear analysis because of its influence on the number of damaging cycles. Simple scaling of a record, of course, alters its amplitude, but not its frequency or duration, although scaling of the time intervals in the record do change these latter parameters. Vanmarke (1979) has suggested that, in order to remain realistic for design purposes, amplitude scaling of not more that a fact of 2 should be used, and Dr Bommer supports this guideline. It was recommended that scaling of time intervals should be as close to unity as possible.

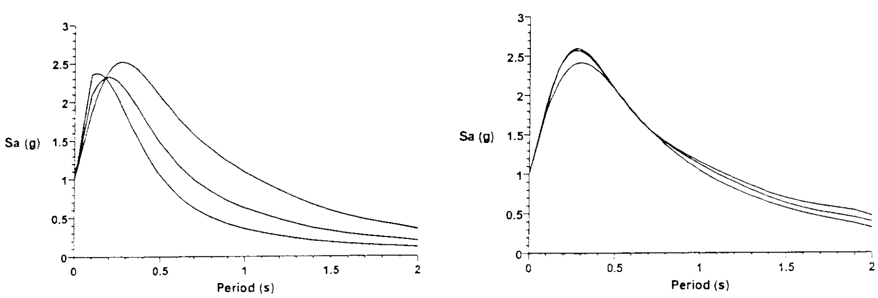


Figure 1 Acceleration response spectra at rock sites, predicted by the relationships of Ambraseys *et al.* (1996): *left*—at 10 km from earthquakes of M_s 5, 6 and 7, *right*—at 5, 20 and 50 km from a M_s 7 earthquake.

Dr Bommer described the results of his studies on the influence of earthquake magnitude on motions (important for amplitude, duration and frequency content), local soils (which also strongly affect relative frequency content) and epicentral distance (on which amplitude is sharply dependent, but which affects relative frequency content much less) – see figure 1. The ideal situation for design would be to have a record from an earthquake with similar magnitude and distance to that considered appropriate for a site, with as close as possible a match to the local soil conditions. However, getting a soil match is usually an unobtainable ideal; even with perfect knowledge it might be difficult to decide whether the soil match is 'good enough' and in practice, only a small percentage of records in the database have even rudimentary information on the local soil at the recording station.

Dr Bommer suggested that the ideal solution is to base the choice of record on ones with appropriate earthquake magnitude and epicentral distance, but captured on rock. The adjustment for the soil effect can then be made analytically, using a program such as SHAKE. Unfortunately, the number of records in the database reported for rock is only about 300; even so, Dr Bommer reported that the database is adequate for selecting a minimum of three time histories which need to be scaled by not more than a factor of 2 (satisfying the Vanmarke rule), provided a magnitude of not more than 7.2 is involved (Fig. 2).

For higher magnitudes, there are gaps in the database, but Dr Bommer pointed out that time will fill them, as more and more high quality accelerometers capture more and more large earthquakes. In particular Dr. Bommer mentioned the expansion of the database in 1999 as a result of earthquakes of magnitude greater than 7 in Taiwan, Turkey and USA. He conceded that use of the 'Green's Function' methods described later by Dr Aspinall may also be used as a temporary expedient to fill the gaps, but his firmly held opinion was that 'artificial time histories', as described by Dr Morris, could never be used for the realistic assessment of non-linear soil or structural response. Further details of the Imperial College work are provided in Bommer and Scott (2000).

Ian Morris, of British Nuclear Fuels Ltd, described some of his company's work on artificial time histories; his full presentation can be found on http://www.ian-morris.freeserve.co.uk.
Artificial time histories are ones that are produced by random vibration theory to match a specified design spectrum, using iterative methods. Some computer programs (such as the Berkeley program SIMQKE) work directly from the spectrum, others (such as SRP sponsored by Westinghouse) use a real time history as a 'seed', which is then progressively modified to get the desired match.

Dr Morris described criteria developed in the nuclear industry in the States to determine the acceptability of artificial histories for a given situation. The criteria were first published some 20 years ago and revised 10 years later; they are set out in ASCE 4 (first published in 1986, but whose long awaited revision will appear shortly) and in the USNRC Standard Review Plan. Similar (though less complete) criteria are given in non-nuclear codes of practice, such as Eurocode 8 and UBC. The criteria cover the minimum number of different generated histories that must be used, the closeness of match between the average spectral values of the time history suite at various frequencies and the design spectrum, and the statistical correlation between the different histories.

A very good match to a target spectrum at a specific level of damping is readily obtained, but matches at other damping levels may be more difficult (figure 3). Cross correlation between the acceleration records also falls well inside the specified upper limits, but cross

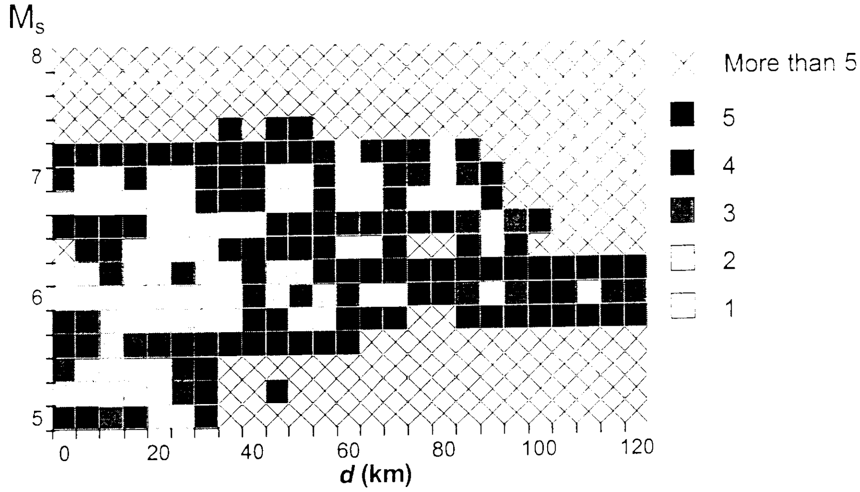


Figure 2 Amplification factor required on basic search window (0.1 M_s and 4 km distance) for each magnitude-distance pair in order to obtain at least three accelerograms from rock sites.

correlation between velocity traces often does not, while the displacement histories are always well correlated. Dr Morris also showed how ones view of correlation in the motion specified by two independent orthogonal histories can be altered simply by evaluating the correlation of the same motion viewed in a rotated co-ordinate system.

Dr Morris described other measures which BNFL use to select artificial time histories that are suitable. The rate of energy release in real earthquakes (as expressed by the Arias intensity $\int_0^t a^2 dt$) or by cumulative absolute velocity $\int_0^t |a|\, dt$) tends to show a sharp initial rise and then level off, while in artificial records, the release is much more even. The form of the displacement time history in real records tends to have a number of cycles, while often artificial records are much less oscillatory (figure 4). As far as possible, artificial histories conforming to the 'natural' characteristics should be sought, provided that they also satisfy the regulatory requirements.

Dr Willy Aspinall, of Aspinall & Associates, described another quite different approach to creating time histories artificially. This technique

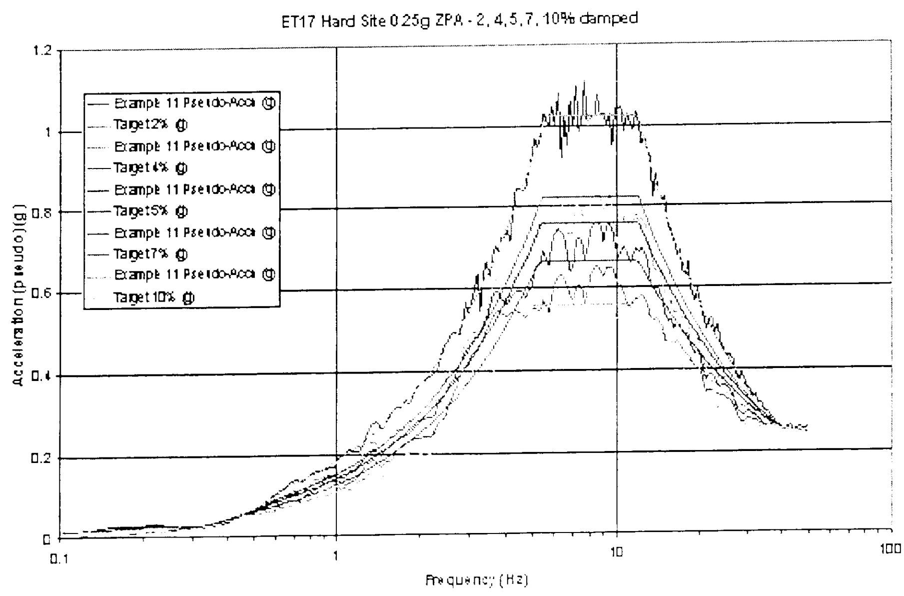
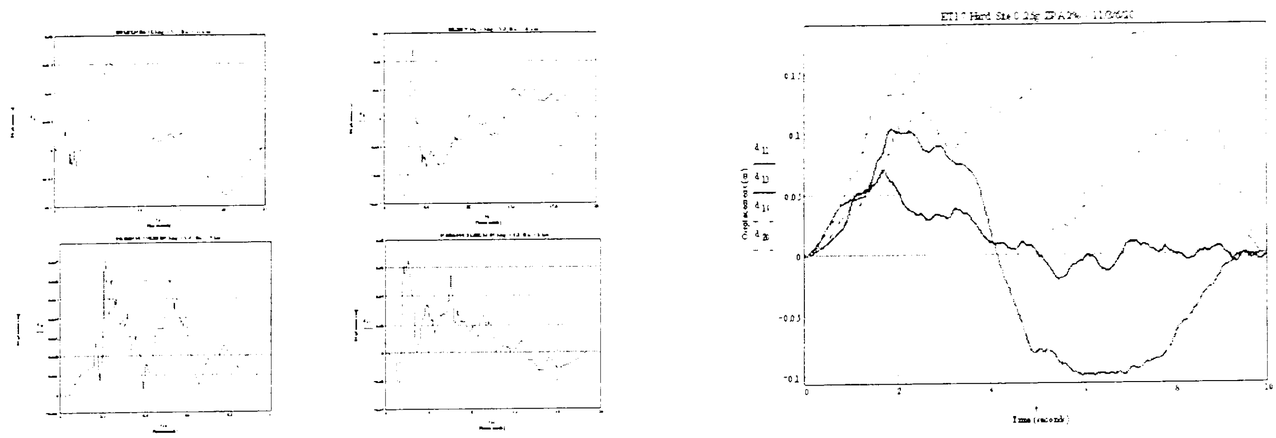


Figure 3 Spectra of artificially generated time history at different damping levels



(a) Displacements of 4 real events similar in size (b) Artificially generated displacements to UK design earthquakes

Figure 4 Displacements from artificial and real time histories

uses the recorded time histories of small earthquakes at a given site to build up a synthetic record of a larger earthquake affecting the same site.

The underlying idea is that the record of a small event represents the break of a fault over a small area; by summing the effects of many such small events, with suitable time delays representing the fault propagation speed, the effect of a much larger fault break – and hence much larger earthquake – can be simulated. Dr Aspinall likened the technique to establishing the modal characteristics of a structure with a series of blows by an instrumented hammer; the signature of each small earthquake recorded represents a 'hammer blow' at a different distance, which can then be built up mathematically, by treating each small record as a 'Green's function', to simulate the effect of a much larger sledge hammer event (figure 5). The main strength of the method is that all the complexity of the propagation path from the source to a given site, i.e. the exact 'transfer function' of the Earth including site response, is uniquely characterized by the real microearthquake time history, whereas this aspect of ground motion is obscured in the 'noise' of traditional attenuation relations or composite spectral shapes based on a mixture of records from many earthquakes and locations.

The number of earthquakes per unit time increases exponentially with decreasing earthquake magnitude. Therefore, for a given site, it takes very much less time to built up sufficient records of small earthquakes to simulate a large design event, than it would to wait for the design event itself (or something near it) to occur.

Dr Aspinall described how the far-sighted decision in the early eighties to install digital arrays of sensitive recording instruments around certain UK nuclear power installations provided large numbers of ground motion records for a site near Hinkley Point. These were sufficient for the technique to be used at this site, and his presentation showed some of the results obtained. He described how synthetic records for the effect of hypothetical magnitude 4 events at the site had been built up from actual records of magnitude 2 and 3 events, for which the fault plane orientation was accurately recorded, and the fault break area could be estimated from published data. The data allowed the effect of a number of different parameters to be investigated. For example, varying epicentral distances were simulated; generally, the predicted attenuation of motion with epicentral distance agreed quite well with attenuation laws published by Principia Mechanica and Imperial College, although the Greens Function accelerations tended to somewhat lower (particularly at low frequencies). The ratio of vertical to horizontal accelerations was predicted to decrease at short epicentral range, contrary to the observation from recent large magnitude events like Kobe. The highest accelerations were predicted when rupture occurred towards the site.

Dr Aspinall described how the technique has also been used by

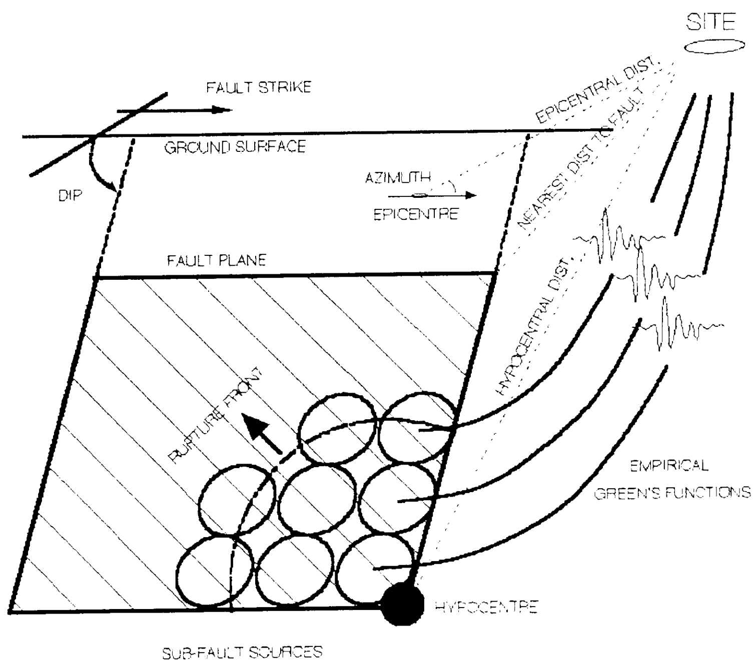


Figure 5 Schematic showing geometrical basis of the empirical Green's function method

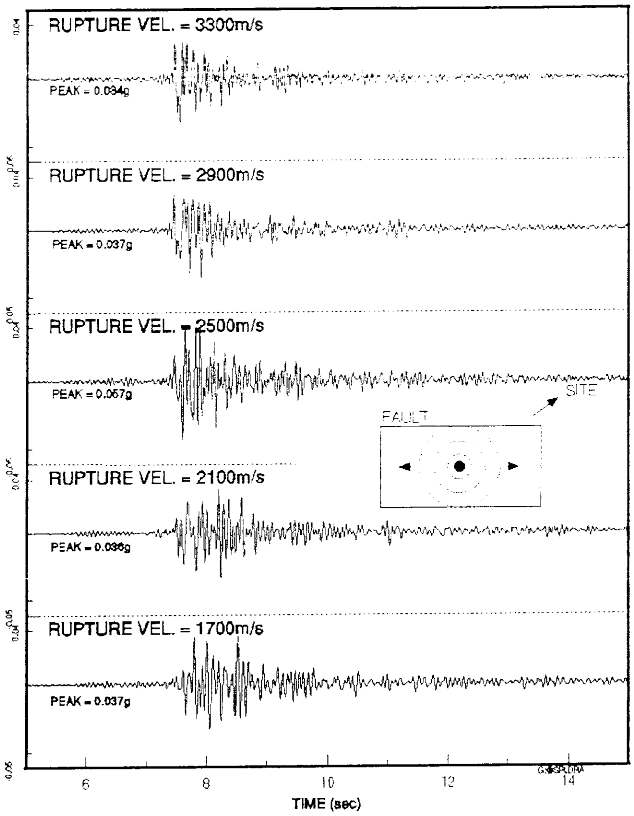


Figure 6 Variation of a simulated acceleration time history with rupture velocity

others to simulate the likely ground motions at a site during a large earthquake, when the site in question did not have a recording instrument installed at the time of the earthquake. By subsequently installing an instrument to capture aftershocks of the main event, the Green's function method has been used to estimate the effect of the Roermond earthquake of 1992 in its epicentral area. There has been a similar use of the technique with the Hinkley Point data to simulate the likely effects of a mediaeval UK earthquake (Glastonbury 1275) in order to explore the feasibility of estimating ground motion from historical accounts of intensity.

A lively discussion followed the main presentations. There was a lot of interest in whether 'realistic' time histories were really available or possible corresponding to the UK design spectra specified by the nuclear industry. Since the general feeling was that these spectra were not realistic, the discussion was not conclusive, although there was a strong body of opinion which felt that the UK nuclear spectral shapes need revision. The dependence of the Green's Function technique on superposition and hence linearity was questioned; Dr Aspinall felt that linearity was a reasonable assumption for UK scale design earthquakes, though it might be more questionable for large interplate events. One questioner felt that a weakness in the Green's Function method was that it relied on assumptions about the fault rupture process, which was poorly understood. Dr Aspinall pointed out that the sensitivity to different assumptions could be tested in the method, and in fact it was found that the predicted ground motion did not change a great deal; a self balancing system seemed to operate where parameters tending to increase motions were offset by others having the opposite effect.

Many important issues were raised in the meeting, and readers are invited to join a virtual debate being hosted on the SECED website until 1st April 2000. Particular issues that readers may wish to comment on may include the following ones.

a) The relationship of code design spectra to real earthquake motions, both for use in the UK and in areas of high seismicity.

b) The ability of artificially generated histories to provide the basis of accurate information on the non-linear response of structures

c) The realism of time histories generated by Green's function methods

d) Choice of magnitude/distance pairs for design events for a given site and return period

To join the virtual debate as a contributor or observer, please access the SECED site http://www.bham.ac.uk/CivEng/seced/ and follow the links.

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Presentations and debate reported by Edmund Booth.

STRENGTHENING OF THE BASILICA OF ST FRANCIS AT ASSISI

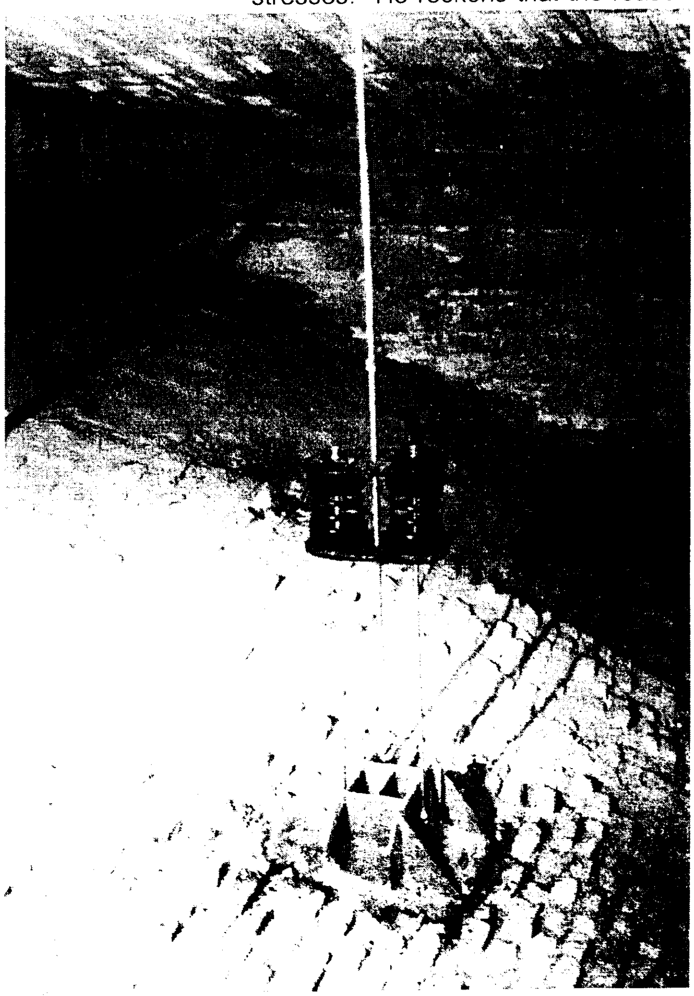
A Report by Edmund Booth on the SECED meeting, 28th September 1999

Professor Giorgio Croci of Universita di Roma gave the Society a gripping account of how bold decisions, careful engineering and hi-tech solutions protected some of the greatest cultural and spiritual treasures of Italy from further destruction by earthquakes. Almost exactly two years before the meeting, a moderate earthquake caused partial collapse of the main vaulting in the Basilica at Assisi, and the loss of rare frescos by Giotto, one of the greatest painters of the early Renaissance. Overall, the damage to the Basilica was extensive and parts of the structures were clearly in a perilous condition, a fact confirmed when a large aftershock caused further damage. As earthquakes continued to strike the region, urgent action was clearly needed; Professor Croci, one of Italy's leading experts on the restoration of historical monuments, was called in to take charge.

Of most immediate concern was the triangular masonry parapet (tympanum) high above the north east end of the building; it was severely damaged, and threatened to collapse onto the roof of a side chapel with important frescos 40m below. A very large mobile crane was needed in the courtyard beneath to erect the shoring required, but a tall medieval wall with small openings blocked its entry. The bold - and risky - solution was to get another very large mobile to lift the first one up and over the wall into the courtyard beyond; the plan worked "but it was not a moment that I would want to experience again" said Professor Croci. The permanent fix was to support the tympanum off reinforced concrete beams via an energy absorbing device, recently developed by LNEC in Lisbon and the University of Thessaloniki. The device consists of pre-tensioned wires made of shape memory alloys, which connected the masonry back to the support beams. The shape memory alloy ensures that although the wires are always in tension, they still form hysteretic loops under cyclic loading and hence absorb energy. Professor Croci said that the use of this innovative device was done mainly on the qualitative judgement that permanent energy absorption would improve response; a quantitative confirmation of the improvement would have to await further research.

The other urgent problem was the main masonry vaulting bearing the priceless Giotto frescos. Four sections had collapsed, but twenty remained, albeit badly cracked. It turned out that the spaces between the main longitudinal walls of the Basilica and the vaulting had become filled with debris over 7 centuries. Prof Croci surmised that under the cyclic movements of successive earthquakes over the ages, the debris had become more and more firmly wedged against the vaulting, causing loss of curvature and severe bending stresses. He reckons that the reason

An anxious moment! – Mobile crane lifting mobile crane into interior courtyard for emergency shoring



Low spring-rate spring providing temporary support to suspended ceiling

Large vertical displacements in the intrados of the Basilica ceiling

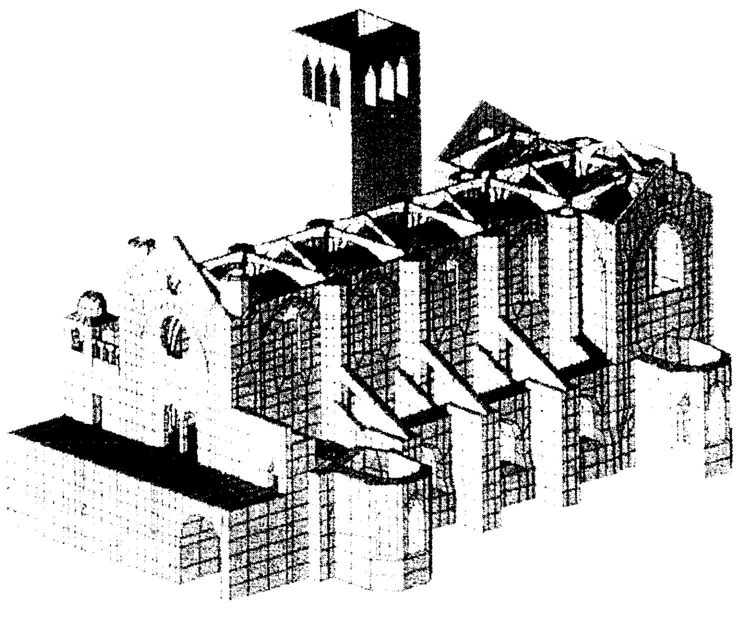
such a moderate earthquake in 1997 caused such extensive damage was that it merely gave the last push to a severely overloaded system.

The action was therefore to remove 1000 tonnes of the accumulated debris and then hang the vaults off temporary bridges spanning between the main walls via low spring rate devices, giving an effectively uniform support pressure, while allowing some movement of the vaults. Too rigid a restraint could have led to very high restraint forces and local failures. Grouting of the cracks in the vaulting then followed, using a carefully devised cementitious mortar designed to avoid damage to the frescos.

A permanent strengthening solution for the vaulting was also needed. Prof Croci chose to add strengthening ribs to the extrados (top side) of the vaulting, similar to those seen on the intrados of traditional gothic roof vaults. However, Croci's ribs were not masonry but were built up in-situ from thin strips of wood, following the curved (and distorted) profile of the vaulting and glued together to form a laminate. The ribs were surrounded by an aramid reinforced fabric to provide additional strength, and then connected down to the vault by glue and by steel stirrups; aramid was chosen as rather more ductile although less strong than carbon. It was a solution sympathetic to the original structural form, which was transparent and potentially reversible, while not interfering with the works of art below. Such novel solutions would probably not have been accepted without interminable debate and discussion had it not been for the urgency of the situation. However, it has still not been decided how to decorate the intrados of the bays which had been rebuilt completely; Prof Croci wondered ruefully how much of the next millennium might be needed to settle that debate.

Finally, Professor Croci had some comments on the reinforced concrete beams added to the main roof structure in the 1960's. Commentators at the time of the earthquake had surmised that these represented rigid restraint points to the vaulting and had been instrumental in the partial collapse. Prof Croci is no great advocator of RC for strengthening historic masonry, but he is adamant that the accumulated debris was the main culprit, not the recent RC beams, which changed the roof stiffness very little.

Edmund Booth



FE Model of the basilica

STOP PROPAGATING DISASTER MYTHS

by Dr. Claude de Ville de Goyet

The international response to the tragic earthquake in Turkey highlights the need to reassess the myths and realities surrounding disasters, and to find ways to stop these destructive tales. The myth that dead bodies cause a major risk of disease, as reiterated in all large natural disasters from the earthquake in Managua, Nicaragua (1972) to Hurricane Mitch and now the Turkish earthquake, is just that, a myth. The bodies of victims from earthquakes or other natural disasters do not present a public health risk of cholera, typhoid fever or other plagues mentioned by misinformed medical doctors. In fact, the few occasional carriers of those communicable diseases who were unfortunate victims of the disaster are a far lesser threat to the public than they were while alive. Often overlooked is the unintended social consequence of the precipitous and unceremonious disposal of corpses. It is just one more severe blow to the affected population, depriving them of their human right to honour the dead with a proper identification and burial. The legal and financial consequences of the lack of a death certificate will add to the suffering of the survivors for years to come. Moreover, focusing on the summary disposal, superficial 'disinfection' with lime, mass burial, or cremation of corpses require important human and material resources that should instead be allocated to those who survived and remain in critical condition.

Our experience in the aftermath of the earthquake in Mexico City showed that health authorities and the media can work together to inform the public, make possible the identification of the deceased and the return of the bodies to the families in a climate free of unfounded fears of epidemics.

The myth that the affected local population is helplessly waiting for the Western world to save it is also false, especially in countries with a large -but unevenly distributed- medical population. In fact, only a handful of survivors owe their lives to foreign teams. Most survivors owe their lives to neighbours and local authorities. When foreign medical teams arrive, most of the physically accessible injured have received some medical attention. Western medical teams are not necessarily most appropriate to the local conditions.

As a professional disaster manager, the press coverage of the Turkey earthquake leaves me with a sense of deja vu: "international rescue teams rushing in are made to look as though they are saving victims neglected by incompetent or corrupt local authorities". We saw the same cliché after major earthquakes and hurricanes in the countries served by the Pan American Health Organization (PAHO) in this hemisphere.

Disaster-stricken countries appreciate external assistance that can do a lot of good when directed to real problems. Unfortunately, too much of the assistance is directed to non-issues or myths. For example, a common myth is that any kind of international assistance is needed, and items needed now, while our experience shows that a hasty response that is not based on familiarity with local conditions and meant to complement the national efforts only contributes to the chaos. It is often better to wait until genuine needs have been assessed. Many also believe that disasters bring out the worst in human behaviour, but the truth is that while isolated cases of antisocial behaviour exist, the majority of people respond spontaneously and generously.

The myth that the affected population is too shocked and helpless to take responsibility for their own survival is superseded by the reality that on the contrary, many find new strength during an emergency, as evidenced by the thousands of volunteers who spontaneously united to sift through the rubble in search of victims after the 1985 Mexico City earthquake or the one in Turkey. Perhaps this cross-cultural dedication to the common good of so many local volunteers and institutions, without red tape or petty institutional turf fights, keeps alive our faith in humankind and society.

The myth that things go back to normal within a few weeks is especially pernicious. The truth is that the effects of a disaster last a long time. Disaster-affected countries deplete many of their financial and material resources in the immediate post-impact phase. The bulk of the need for external assistance is in the restoration of normal primary health care services, water systems, housing, and income producing work. Social and mental health problems will appear when the acute crisis has subsided and the victims feel (and often are) abandoned to their own means. Successful relief programs gear their operations to the fact that international interest wanes as needs and shortages become more pressing.

Natural disasters such as the tragic Turkey earthquake do not result in imported diseases that are not already present in the affected area, and they do not provoke secondary disasters through outbreaks of communicable diseases. Proper resumption of public health services, such as immunization and sanitation measures, control and disposal of waste, and special attention to water quality and food safety, will ensure the safety of the population and of relief workers.

It is essential that the press and the donor community be aware of what is good practice and malpractice in public health emergency management. Past sudden-impact natural disasters in the Americas and elsewhere have shown the need for international contributions in cash and not in kind. This ensures that allocation of resources is field-driven by evidence of what is needed on-site. The population in Turkey does not need used clothing, household or prescription medicines, blood and blood derivatives, medical or paramedical personnel or teams, field hospitals and modular medical units. They want, as do any victims of disasters, to rebuild safer houses, have their "normal" health problems attended at the health centre, put their children in school and get back to their lives. Unilateral contributions of unrequested goods are inappropriate, burdensome, and divert resources from what is needed most.

There are lessons to be learned. While it is true that the Turkish authorities were unprepared, who is ever ready for a disaster of this magnitude? The World Health Organization should have done more to strengthen the local capacity, but with what resources? The U.S. and other countries spent millions of dollars to dispatch search and rescue teams - who arrived after the most critical first hours or days - to a country where thousands of local medical doctors volunteered their services. A small part of this money could have been more effectively applied in preparedness and prevention activities.

We need to educate donors just as we need to educate potential victims of disasters. A little preparedness can go a long way toward alleviating the "secondary" disasters often visited on countries. Increased funding for the U.S. Office of Foreign Disaster Assistance for disaster preparedness and prevention in the third world and more funding from other bilateral or international agencies could help matters.

If donors would commit now to strengthen the local capacity to respond to future disasters in Turkey, in the disaster-prone countries of the Americas, and other places, and learn what is important and what is futile in helping countries, the world would be better off.

Dr. de Ville de Goyet has been, since 1977, Chief of the Emergency Preparedness and Disaster Relief Coordination Program at the Pan American Health Organization, regional office for the Americas of the World Health Organization. The organization's web site address is:
http://www.paho.org/english/ped/pedhome.htm

SECED / IMPERIAL COLLEGE SHORT COURSE: AN INTERNATIONAL SUCCESS!

In total, participants in the course, which was also sponsored by the European Association for Earthquake Engineering (EAEE), came from a total of 16 countries. Almost two-thirds of the participants on the course were from the UK, these delegates representing 21 engineering companies, the Ministry of Defence and the Health and Safety Executive. 15 participants in the Short Course came from further afield: The Netherlands, Portugal, Greece, Italy, Malta, Sweden, Egypt and even China. Another 14 overseas participants were sponsored by SECED having been put forward by their national Associations for Earthquake Engineering affiliated to the EAEE. These delegates came from the Czech Republic, France, Germany, Greece, Iran, Italy, Macedonia, Spain and Turkey.

The course evaluation is still being processed, but the comments and immediate feedback from delegates was very positive. The course managed to cover a great deal of material in just three days, including the basics of hazard assessment, geotechnical earthquake engineering, method and principles of seismic design, seismic design of reinforced concrete and steel structures and assessment and repair. All of the sections of the course were illustrated with practical examples from engineering projects in which the speakers have been involved. Several points were also illustrated by observations and back analyses from recent earthquakes. These even included data from the earthquakes in Izmit and Athens, which occurred just weeks prior to the course, obtained by members of EEFIT and EFTU.

One point of interest is that when the question was put to the delegates at the opening session, it was apparent that at least one third of the UK participants were not SECED members. This confirms that the UK earthquake engineering is much larger than the current membership of our Society and it is a task for all of us to encourage others to join SECED.

Julian Bommer

Imperial College Earthquake reports available on CDROM

Three visual reports on one CDROM in the form of PowerPoint files with images of damage and analytical work, including elastic and inelastic spectra as well as inelastic dynamic response analyses of multi-storey structures.

ESEE98-5: The Adana-Ceyhan (Turkey) Earthquake of July 1998; Observations Statistics & Strong-Motion Analysis. This presentation contains 74 slides from the Ms=6.3 earthquake in south-eastern Turkey, which caused extensive damage in a large area of modern buildings and industrial facilities. The most important records from this earthquake are analysed and elastic and inelastic spectra are presented. Images covering ground deformation and structural damage as well as repaired structures are included.

ESEE99-3: The Kocaeli (Turkey) Earthquake of 17 August 1999; Assessment of Spectra & Structural Response Analysis. This presentation contains 117 slides from the Ms=7.6 earthquake in north-western Turkey. It includes aerial photographs, images of structural damage and ground deformation and extensive analysis of the strong-motion records. Comparison of structural responses from this earthquake and other earthquake records (one from Northridge and another artificial record representing a European earthquake with a 975 years return period) are given for non-seismic 4 storey 3 bay RC structure. Test results for a full-scale frame are also presented to emphasise the realism of the analytical results.

ESEE99-4: The North Athens (Greece) Earthquake of 7 September 1999; Analytical Studies of Structural Response. This presentation contains 97 slides from this Ms=5.6 earthquake 20km north of Athens. Records from central Athens are studied and presented using elastic and inelastic spectra. Two structures are analysed (a six storey flat slab structure and a four storey infilled frame) and the latter is also selected for studies of short columns, soft storey and excessive concentrated masses. Images from the damaged areas of residential and industrial structures are also given.

The CDROM is available from Angela Bishop (Tel: 0171-5946056, Fax: 0171-5946053, Email A.Bishop@ic.ac.uk, ESEE Section, Imperial College, London SW7 2BU). Price £12.00 plus £1.50 postage and packaging.

SECED Directory: Millennium Edition

A new millennium edition of the SECED Directory of Practitioners in Earthquake Engineering & Civil Engineering Dynamics is in preparation. The SECED Directory provides an authoritative guide to UK consultants, suppliers, testing laboratories and research organisations active in the field of earthquake engineering and civil engineering dynamics, including blast and impact engineering and noise and vibration engineering.

Those organisations that had an entry in the 1997 edition will be contacted directly. Organisations who wish to have an entry in the new edition and which were not in the 1997 edition are invited to contact the SECED secretary (details on the back page) or John Donald at jse.donald@tesco.net for details of the content of the directory and its distribution.

NOTABLE EARTHQUAKES JULY - SEPTEMBER 1999

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
1999	03	JUL	01:43	47.08N	123.46W	41		5.4	5.5	WASHINGTON
			At least 7 people injured and buildings damaged in the Aberdeen-Satsop area.							
1999	07	JUL	14:31	51.70N	3.22W	2	1.9			BARGOED, MID GLAM
			Felt throughout Blackwood with maximum intensities of 3 EMS.							
1999	11	JUL	14:14	15.81N	88.34W	10		5.9	6.6	HONDURAS
			At least 2 people were killed and 40 injured.							
1999	13	JUL	16:33	49.21N	2.32W	10	1.8			JERSEY, CHANNEL ISLANDS
			Felt throughout Jersey with maximum intensities of 3 EMS.							
1999	19	JUL	17:58	56.38N	4.18W	3	2.0			LOCH EARN, CENTRAL
			Felt throughout St Fillans.							
1999	21	JUL	17:43	18.34N	101.47W	67		6.0		GUERRERO, MEXICO
			At least 600 houses were damaged at Coahuayutla, Guerrero.							
1999	24	JUL	02:03	55.10N	3.64W	11	1.3			DUMFRIES, D & G
			Felt Tinwald with maximum intensities of 3 EMS.							
1999	30	JUL	09:31	51.69N	3.20W	6	2.7			BARGOED, MID GLAM
1999	31	JUL	03:15	56.14N	3.69W	1	1.4			CLACKMANNAN, CENTRAL
			Felt Forest mill with maximum intensities of 2 EMS.							
1999	10	AUG	19:33	36.18N	54.62E	33		4.5	4.1	NORTHERN IRAN
			One person killed several injured and buildings damaged at Momenabad.							
1999	17	AUG	00:01	40.70N	29.99E	17			7.5	IZMIT, TURKEY
			At least 15,000 people were killed, approximately 24,000 injured and thousands missing. Approximately 600,000 people left homeless and extensive damage occurred throughout the provinces of Istanbul, Kocaeli and Sakarya.							
1999	20	AUG	10:02	9.24N	84.13W	33		6.0	6.8	COSTA RICA
			Felt throughout Costa Rica.							
1999	29	AUG	22:59	55.10N	7.74W	10	1.5			DONEGAL, IRELAND
			Felt Letterkenny.							
1999	31	AUG	08:10	40.71N	29.95E	10		5.2	4.9	TURKEY
			One person killed, approximately 170 people injured and additional damage caused throughout the Izmit area.							
1999	01	SEP	05:00	53.20N	4.35W	17	3.2			CAERNARVON, N WALES
			Felt throughout Holyhead, Llangefni, Menai Bridge, Bangor and Caernarvon with maximum intensities of 4 EMS. This event was followed by a magnitude 1.1 ML aftershock at 05:26 UTC which was felt with intensities of 3 EMS.							
1999	03	SEP	22:57	55.23N	3.40W	6	2.1			JOHNSTONEBRIDGE, D & G
			Felt throughout Lockerbie and Dumfries with maximum intensities of 3 EMS.							
1999	07	SEP	11:56	38.14N	23.66E	15		5.6	5.8	GREECE
			At least 135 people were killed, more than 1,600 injured and 50,000 people left homeless. More than 34,900 buildings were destroyed or damaged in the Athens area.							
1999	07	SEP	12:01	52.93N	2.27W	3	2.6			NEWCASTLE-U-LYME
			Felt at Keele University with intensities of 3 EMS.							
1999	20	SEP	17:47	23.73N	121.12E	33		6.6	7.6	TAIWAN
			At least 2,100 people have been killed, approximately 8,000 injured and as many as 12,000 houses destroyed.							
1999	25	SEP	23:52	23.72N	121.20E	17		6.2	6.4	TAIWAN
			Five people were killed and approximately 60 injured.							
1999	30	SEP	16:31	16.12N	96.87W	63		6.6		OAXACA, MEXICO
			At least 33 people were killed, approximately 160 injured and over 20,000 buildings were damaged.							

Issued by Bennett Simpson, British Geological Survey, August 1999

Forthcoming Events

19 January 2000
Zone-Free Hazard Modelling
ICE 2.00pm (Half Day meeting)

23 February 2000
Seismically Triggered Landslides
ICE 5.30pm

16-17 March 2000
UK/US/FR Seminar - Seismic Design of Bridges
Email: Conferences@istructe.org.uk for more details

22 March 2000
Recent Destructive Earthquakes
SECED/EEFIT/EFTU Joint Meeting
ICE

26 April 2000
The Cost of Earthquakes
ICE 5.30pm

24 May 2000
Blast and Impact Effects on Structures and Materials

Contents

SECED Newsletter

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

Diagrams should be sharply defined and prepared in a form suitable for direct reproduction. Photographs should be high quality (black and white prints are preferred). Diagrams and photographs are only returned to the authors on request. Diagrams and pictures may also be sent by Email (GIF format is preferred).

Articles should be sent to:

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SECED

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

It is also sponsored by the Institution of Mechanical Engineers, the Institution of Structural Engineers, and the Geophysical Society. The Society is also closely associated with the UK Earthquake Engineering Field Investigation Team. The objective of the Society is to promote co-operation in the advancement of knowledge in the fields of earthquake engineering and civil engineering dynamics including blast, impact and other vibration problems.

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