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In this issue

Report on the *Nuclear Design for Extreme Events* Seminar

at Haydock Park 16th June 2010

Andrew Mair
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The joint SECED / Nuclear Institute seminar held at Haydock Park Racecourse on 16th June 2010, proved to be a popular event with over 80 engineers attending from all parts of the nuclear industry and academia. The one day conference included presentations on seismic engineering, design for blast and impact and a session on new build for nuclear power generation. The day culminated with a keynote address from Professor Julian Bommer on the subject of seismic hazard assessment.

The seminar was chaired and opened by Dr Andrew Mair of Jacobs, who in his opening remarks commented on the significant advances made in the UK nuclear industry over the past 50 years or so, and the influence of seminal events like the Sizewell B Public Inquiry, which shaped much of what has become the modern Nuclear Safety Case. Extreme events, by their very nature, can be difficult to comprehend, and the return periods associated with their occurrence make them difficult to relate to every day life. Occasionally we get reminders of smaller events in the UK to jolt our senses, like the recent events at Folkestone and Market Rasen, or indeed larger events on the world stage like the Boxing Day 2004 tsunami. With extreme events we are seldom dealing with issues that are black and white, but rather many shades of grey, where there can be significant uncertainty. We frequently find ourselves in the realms of expert opinion, and we need to be careful how we elicit that opinion and how we use it in our decision making.

As the industry moves in to a new era, with the prospect of new nuclear power stations being commissioned in the UK, addressing extreme events is arguably more challenging that ever. With a number of new entrants to the UK market, both as potential licensees and plant vendors, the challenges of maintaining a consistent approach across the licensees, the various elements of the supply chain and the Regulators will not be inconsiderable.

The first session of the seminar was on the subject of seismic engineering, with presentations from Dr Paul Smith of AMEC, Paul Doyle of Jacobs and Ian Morris of National Nuclear Laboratory. Paul Smith spoke on the topic of performance based seismic design of nuclear facilities, giving an overview of the state of the art in this subject area. In his presentation he examined the regulatory requirements for seismic assessment in the UK, USA, France and South Africa, highlighting the difference between prescriptive and non-prescriptive regulatory approaches. A methodology for conducting performance based seismic design was

Speakers at the NDEE 2010 seminar
Back row left to right: Ian Morris, Winston Blackshaw, Paul Doyle, Andrew Mair
Front row left to right: Andy Howarth, John Donald, Julie Gorgemans, Julian Bommer, Keith Ardon
(Paul Smith missing from photograph)

proposed, backed-up by an illustrated example of work on equipment support frames. The example demonstrated that although an item of equipment may not be compliant with traditional capacity based design methods, it still fulfilled its performance goals. The inelastic assessment criterion developed for the specific item of equipment was based on materials testing results.

Paul Doyle discussed the development of seismic criteria for the design of new facilities at AWE, Aldermaston. AWE is currently developing a range of new nuclear facilities, many of which have safety functions related to seismic behaviour. In addition, existing facilities need to have periodic reviews of safety, with review against modern criteria for seismic design. As a responsible licensee, AWE needs to control the work undertaken and to ensure that unnecessary expenditure is avoided whilst still maintaining nuclear safety. Paul discussed the new seismic documentation that has been prepared to address these requirements, with particular reference to performance criteria, regulations, codes and standards, ductile detailing and seismic design of plant.

As part of the background to the development of the new criteria, Paul discussed the specification of seismic motions, and the selection of mandatory elements and non-mandatory elements for seismic design, and assessment of structures, systems and components in new and existing plants. He went on discuss the performance classes for structures (elastic response, containment, moderate damage and no collapse) and performance classes for plant (continuous operation, post-event functionality and fail-safe). In his presentation Paul emphasised the importance of ductility in the design of structures and gave examples of how to achieve this in reinforced concrete and steel structures.

Ian Morris gave a detailed presentation on the seismic qualification of plant and equipment, in which he outlined the many steps involved and discussed alternative approaches. He defined plant and equipment as "anything that is not the building structure and foundations". The seismic demand was described in terms of the performance requirements and the seismic loading, whilst the capacity of the plant and equipment was considered in terms of the acceptance criteria and the calculation/analysis methods used. Examples of establishing acceptance criteria were given by using established design methods, shake table testing, stress based analysis and the use of design codes. Ian gave a particularly interesting insight into alternative approaches for dealing with missing mass in modal response spectrum analysis and in the differences between real and artificial time histories.

The second session of the seminar was devoted to the subject of impact, with Winston Blackshaw of Sellafield Ltd talking on the subject of aircraft impact, and Andy Howarth of National Nuclear Laboratory talking on the subject of impact studies on nuclear facilities with particular emphasis on finite element modelling. In his presentation, Winston Blackshaw outlined the general philosophy and approach taken for the building and plant design with respect to aircraft impact loading. Safety and structural performance requirements were reviewed and general design concepts discussed. Typical building and plant designs were presented and specific design considerations highlighted.

A major challenge for the nuclear industry is the substantiation of transport packages containing nuclear materials against extreme event dropped loads, where the packages are required to meet strict performance requirements to prevent leakage and criticality. Andy Howarth highlighted the important role that finite element analysis plays in assessing various impact accident scenarios on transport packages, where other calculation methods may be unsuitable and the prospect of physical testing is limited or not an option. FE models can, of course, also be used to assess the effects of the impact on the building structure itself, as well as the package and its contents. In his presentation Andy discussed the key considerations for assessing an impact scenario, giving examples of how modelling can be used at the conceptual design stage, and also in the detailed design of mitigating safety features that ensure the safe transport of material when existing equipment must be used. He illustrated his talk using several examples of real situations, including excellent time history animations. Andy demonstrated how many hypothetical scenarios could be assessed relatively cheaply, with the results being used to refine the design, develop mitigating features, determine the safety margin or provide input to testing regimes.

The third session of the day was devoted to the new build programme of nuclear power stations in the UK, with presentations from Julie Gorgemans of Westinghouse, Keith Ardon of Areva and John Donald of the Health & Safety Executive Nuclear Directorate. Julie and Keith gave an overview of the Westinghouse AP1000 and Areva EPR reactor and nuclear island designs respectively, both of which represent the current state of the art in reactor design, but which are quite different in terms of their size, output and cost.

The AP1000 is a Generation III+ reactor design, featuring passive emergency core and containment cooling systems. This means that the active systems required to mitigate and control accident conditions in other PWR designs, for example safety injection or containment cooling, have been replaced by simpler systems relying on gravity, compressed gas expansion, or natural circulation as driving functions, rather than pumps and emergency diesel generators. An objective of the AP1000 design is to simplify construction, maintenance and operational issues, thus giving a competitive cost for the power produced, whilst increasing operational and safety margins.

Subject to regulatory approval, EDF Energy plans to construct 4 EPR units in the UK. The EPR is at the opposite end of the spectrum in terms of size from the AP1000, being a larger, more powerful and more expensive design. It has a high level of protection against external hazards, which is achieved by applying deterministic design principles using a load case approach. In his presentation, Keith Ardon outlined the external hazards considered explicitly in the EPR design and described the protection principles for key examples, including seismic events, aircraft crash, external explosion and external flooding.

John Donald spoke on the regulation of external hazards in the context of the new reactor programme, and discussed both the Nuclear Directorate's Generic Design Assessment (GDA) of the proposed designs and the site specific external hazards. He identified the two dominant external hazards as being seismic and malicious aircraft impact.

John covered several topics in his talk, including the design approach, the importance of verification and validation of analysis and design, the benchmarking of codes, and the need for a shared understanding of the conservatisms and standards throughout the design process across all the disciplines, e.g. soil-structure interaction, civil/structural design, systems and components. In terms of the planning and execution of the work he identified the need for clear targets and control hold points within the construction schedule, as a key element in the control of the construction process. John also emphasised the importance of passing the Safety Case knowledge through the life of the plant, from the design process, through construction and into operation and maintenance. The operation and maintenance teams need to know what elements of the plant are qualified and understand why and how they are qualified.

The event was closed with a Keynote Address from Professor Julian Bommer of Imperial College, who spoke on the topic of a new paradigm for seismic hazard assessment at UK nuclear power plant sites. Professor Bommer began his talk by looking at the requirements of the NII Safety Assessment Principles in respect of a seismic hazard assessment, particularly that the design basis event should be that which conservatively has a predicted frequency of not being exceeded of 10^{-4} per annum. He went on to emphasise the need to demonstrate that the assessment of the seismic design actions has taken

John Donald of HSE Nuclear Directorate giving his presentation at NDEE 2010

full account of all uncertainties, both aleatoric (random variability) and epistemic (lack of knowledge). Julian explained the basics steps in carrying out a probabilistic seismic hazard assessment (PSHA) and discussed some of the areas of epistemic uncertainty, including seismic sources, recurrence rates and attenuation relationships. He illustrated the potential effects of epistemic uncertainty by citing two PSHA studies conducted in the 1980's for nuclear power plant sites in the Eastern and Central USA. In both projects seismic hazard experts developed their seismic hazard models independently and arrived at very different results, with large expert to expert variation and large differences between the hazard estimates from the two projects. As a result of these findings the US Department of Energy, EPRI and the Nuclear Regulatory Commission formed the 'Senior Seismic Hazard Analysis Committee' (SSHAC) to review how these studies were conducted and to propose improved procedures. The SSHAC concluded that many of the pitfalls in conducting a PSHA were procedural rather than technical, and subsequently published what has become known as the SSHAC guidelines.

Julian closed his talk by questioning how new seismic hazard studies should be done in support of the new nuclear build programme in the UK. He stated that many of the elements of a seismic hazard study would be common to all site specific PSHAs, and in this respect it would be appropriate to make full use of the relatively small pool of UK seismic hazard experts working together as one group. He proposed an organisational model for PSHA of new nuclear sites in which a UK seismic source characterisation model and a UK ground motion model would be developed by a UK seismic hazard team, which would be funded by collective industry sponsorship. He suggested that this work should adopt a SSHAC Level 3 approach. For each specific site, the local seismic sources/active faults and the site response analysis would be addressed by a local seismic hazard team appointed by the Site Licensee.

Professor Bommer's talk stimulated a lively and informative discussion, as indeed did the talks of the other speakers throughout the day. Judging by the feedback received from the delegates, it would appear that most of the participants had their objectives of attending met.

Acknowledgements

The Nuclear Design for Extreme Events seminar was jointly organised by SECED and the Nuclear Institute, both of whom gratefully acknowledge the sponsorship received from ANSYS. As is often the case with events like these there are many to thank, but it was a few individuals who put in the real organisational effort to make the event the success that it was. In this respect, a special thank you is appropriate to Andy Campbell, Robert Haymen and Ian Currie.

SECED Earthquake Prediction Competition celebrates 15 years: 1996-2010

Alice Walker & Davie Galloway
British Geological Survey, Edinburgh

This long running competition has been a feature of the SECED AGMs for fifteen years. It started after a brief conversation between David Mallard and Chris Browitt in 1996 and has proved popular over the years with up to 60 squares taken annually. As we know, earthquakes of magnitude 2.5 M_L and above are fairly common in the UK (more than 1 per month) with most of those, onshore, being felt by people. They are monitored by the British Geological Survey's network which has been recording earthquakes for some 40 years.

Eleven of the winning earthquakes have been felt by the local population but not in the last three years. This may be a result of the information being rapidly available on the BGS website and, as a result, no-one telephones to request information and report what they felt – at least, for the smaller events. In all but one case, a winner of the competition has been found within 28 days (the exception was 37 days). This year's winner is Chris Browitt, of Edinburgh University, who correctly guessed that the next earthquake above 2.5 M_L in the UK, would occur in square 79 (see illustration on opposing page). The Gainsborough earthquake of 19 June occurred, here, at 10:17 in the morning, with a magnitude of 2.7 M_L. Chris received the usual prize of a bottle of champagne at the SECED meeting on 24 November on the occasion of a presentation on "Non-Linear Soil-Structure Interaction: A Requirement for Performance Based Design of Foundations" by Alain Pecker.

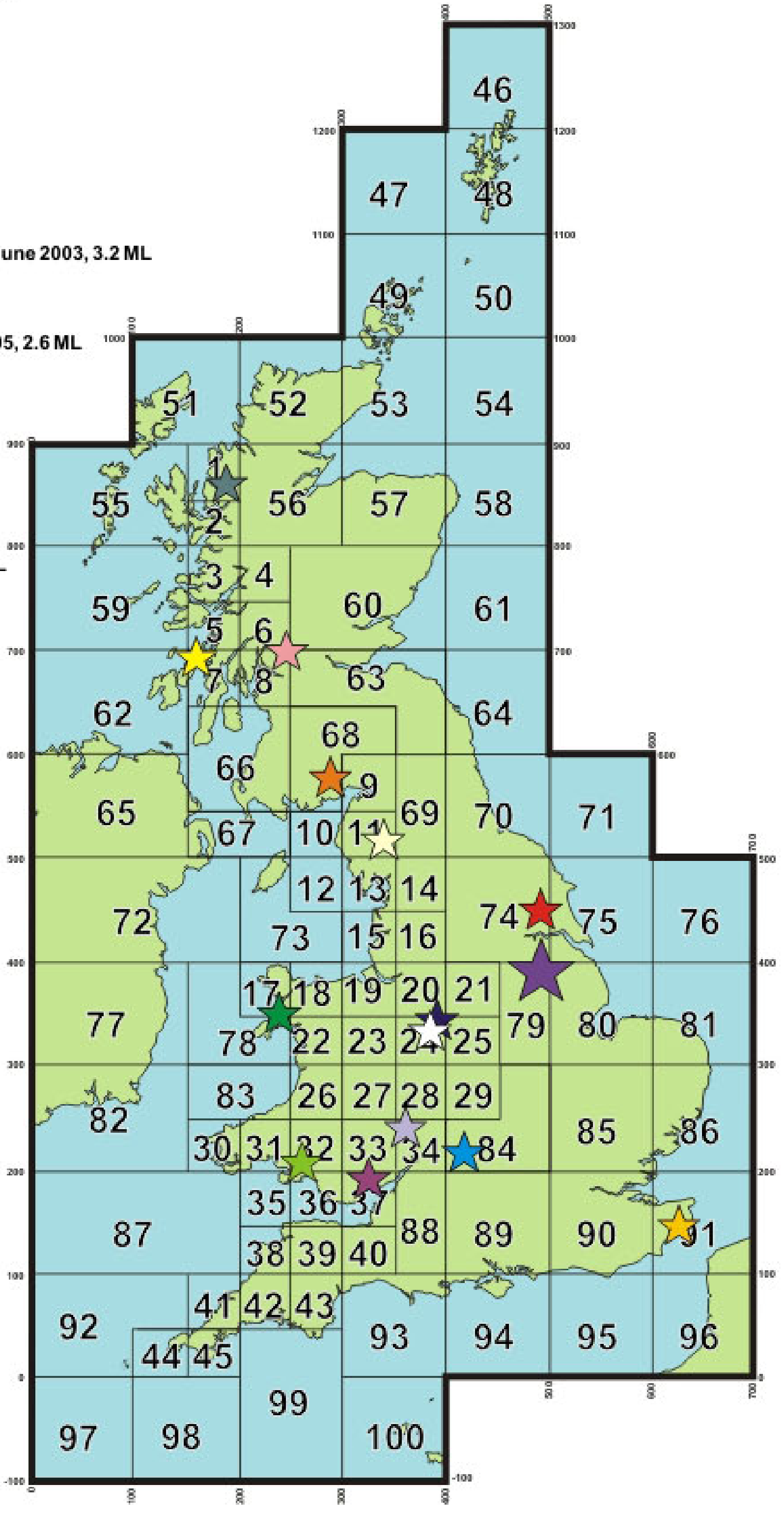
The full list of winners, together with the distribution of winning earthquakes over the past fifteen years, is shown on the next page. For further information on earthquakes in the UK, please visit www.earthquakes.bgs.ac.uk.

SECED EARTHQUAKE COMPETITION RESULT 2010

★ **Chris Browitt, Edinburgh University - Gainsborough, 19 June 2010, 2.7 ML**

EARTHQUAKE COMPETITION WINNERS 1996 - 2010

- ☆ Nigel Hinings - Stoke-on-Trent, 6 May 1996, 2.8 ML
- ★ Tony Blakeborough - Carterton, 19 May 1997, 2.7 ML
- ★ Dene Wilson - Jura, 3 May 1998, 3.5 ML
- ★ Robin Adams - Hereford, 17 June 1999, 2.8 ML
- ★ Robert May - Lleyn, 22 June 2000, 2.7 ML
- ★ Paul Doyle - Dumfries, 13 May 2001, 3.0 ML
- ★ Peter Merriman - Cardiff, 20 June 2002, 2.9 ML
- ★ Harry Wahab & Riccardo Sabatino - Aberfoyle, 20 June 2003, 3.2 ML
- ★ Chris Browitt - Driffield, 5 July 2004, 2.6 ML
- ★ Piroozan Aminossehe - Stoke-on-Trent, 8 June 2005, 2.6 ML
- ★ Matthew Free - Shieldaig, 8 June 2006, 2.9 ML
- ★ David Mallard - Folkestone, 28 April 2007, 4.3 ML
- ☆ Andrew Coatsworth - Penrith, 28 May 2008, 2.5 ML
- ★ Zygi Lubkowski - Llannon, 6 October 2009, 2.5 ML
- ★ Chris Browitt - Gainsborough, 19 June 2010, 2.7 ML



Roger Musson has sent a report on seismic hazard in the UK following Julian Bommer's contribution on the harmonization of seismic hazard assessments in Europe, in the last Newsletter.

General levels of seismic hazard in the UK

R.M.W. Musson
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When the hazard mapping study for the application of Eurocode 8 to the UK was commissioned, it was part of the brief that conservatism should not be used as a guiding principle in the study (Booth 2007, Musson and Sargeant 2007). Even so, when the results were published, there was some surprise expressed at quite how low the results were compared to other studies. A recent paper by Lubkowski et al (2010) has updated an earlier PSHA study for the UK (Arup 1993) and has reported that the authors found hazard values significantly higher than those of Musson and Sargeant (2007) especially in areas of lower seismicity. They comment that "these differences may have a reasonable explanation".

As a general principle, when two studies of the same thing come up with different answers, one feels a lot more comfortable if one can at least understand the reasons for the differences. Inexplicable inconsistencies create unease. Fortunately, there is indeed a reasonable explanation for the discrepancy in results. It is clear why these two studies give contrasting results for UK hazard, and so it may be helpful to the readership of SECED Newsletter to set out the explanation. It also provides an instructive example of how, in PSHA, it is sometimes the case that decisions made on an ostensibly reasonable basis turn out to have unforeseen consequences.

There are two main reasons for the differences between the two studies. The first relates to the observation in Lubkowski et al (2010) that the discrepancy in results was most marked in areas of low seismicity. This is due to differences in the source models. Arup (1993) used a three-part model (thus including an element of epistemic uncertainty), which was adopted by Lubkowski et al (2010) and shown in Figure 1 of that study. Musson and Sargeant (2007) adopted a single set of source zones, based partly on tectonics and partly on seismicity, as agreed by the steering panel for the project (Booth 2007).

The different philosophies behind the two models can be illustrated with respect to the example of the seismicity of Snowdonia. In the historical record, Snowdonia appears as a "hot spot", with earthquakes > 4.5 M_W occurring in 1534, 1690, 1852 and 1984, with many smaller events also. The approach taken in Musson and Sargeant (2007) is to argue that a pattern that has been stable for the last 500 years is likely to persist at least for the lifetime of structures built today. Thus the study models future seismicity in North-West Wales at the same rate as historically observed. The result of this is that North-West Wales figures in the hazard maps produced by the study as a prominent peak of high values. By contrast, the Arup (1993) model, with 60% certainty, treats the Snowdonian seismicity as equally likely to migrate to anywhere over a wide area, including places like Belfast, which has been aseismic throughout the historical record. One branch of the Arup (1993) model, with 30% weight, treats seismicity as homogeneous throughout the whole of Great Britain.

It is clear that this approach will smooth out the hazard over the whole country, raising it in low-seismicity areas and depressing it in high-seismicity areas. Thus it is not surprising that the differences between Lubkowski et al (2010) and Musson and Sargeant (2007) are most noticeable in low-seismicity areas.

However, the main discrepancy between the results is related to the earthquake catalogues used. Catalogue preparation is a task that is often considered more straightforward than it really is, and there are hidden pitfalls.

The catalogue used by Lubkowski et al (2010) is derived from two sources: for the period up to 1990, the catalogue from Arup (1993) is used, with surface-wave magnitude (M_S) converted to moment magnitude (M_W) using a relation from EPRI (1994) for stable continental regions. For the subsequent period, BGS data is used, converted from local magnitude (M_L) to M_W using an equation from Grünthal et al (2003), derived from a large European data set north of the Alps.

How far are these data sets compatible? For easier comparison, one can take the Arup catalogue (in M_W) from 1700-1969 (which should be a complete set) and the BGS data from 1970-2007 above 3 M_W (which should also be complete). Figure 1 shows these two data sets compared for magnitude frequency. They are clearly incompatible. Since it seems unlikely that the *b* value for Great Britain drastically jumped in 1970 (with a change in the recurrence interval

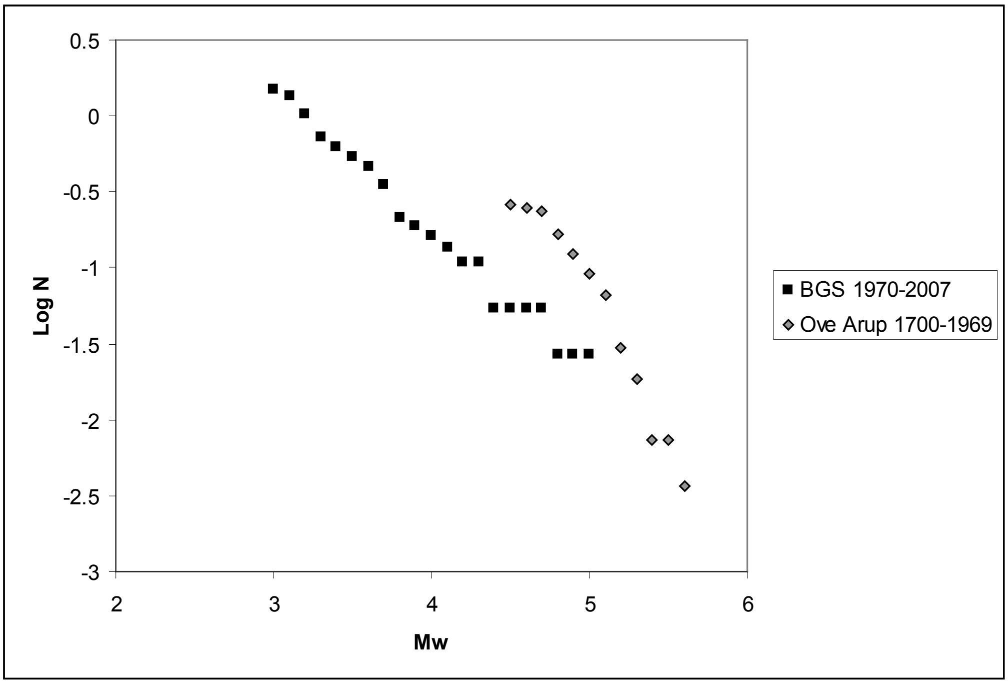

Figure 1. Comparison of Arup and BGS earthquake catalogues

of events > 4.7 M_W from 4 years to 18 years), something must be wrong with one of the data sets.

Marrow (1992) compared BGS magnitudes to those from neighbouring European agencies, for events in common, and found good agreement. The conversion from M_L to M_W used by Lubkowski et al (2010) is the same as was used by Musson and Sargeant (2007); it is well constrained from a large set of North European data and has been shown to agree with unpublished BGS M_W determinations. The Arup (1993) catalogue agrees with other UK studies that have included M_S determinations for the same events, and it seems highly improbable that there are any serious issues with it.

So by process of elimination, one has to look critically at the M_S to M_W conversion, which is the one element that is not locally verified. At first glance, the choice of EPRI (1994) seems unproblematic, given that the relation is similar to those for M_S to M_W given by Ekström and Dziewonski (1988), and Scordilis (2006).

Some historical context (necessarily simplified) is helpful here: M_S was originally proposed by Gutenberg and Richter (1936) and Gutenberg (1945) as an extension of Richter's (1935) original M_L scale, which saturates around 6. So M_S was originally intended for larger earthquakes recorded at teleseismic distances, and was calculated from surface waves with a period of 20 seconds, although in fact, Gutenberg was not very careful about documenting his procedures, and his working notes show he also picked amplitudes at other periods.

Work in the 1950s and 1960s, especially in the Soviet Union, sought to regularise the definition of M_S, and produced the so-called “Prague formula” of Vanek et al (1962), which was adopted as the international standard by the International Association for Seismology and the Physics of the Earth's Interior (IASPEI). However, there has been a tendency ever since to assume that use of the Prague formula still implies picking amplitudes at 20 seconds period (e.g. Herak and Herak 1993, Bonner et al 2006). This is not true, but few people have actually read the original 1962 paper. Vanek recently confirmed that it was never the intention to confine use of the scale to 20 s amplitudes (Vanek, pers. comm. to Peter Bormann, 2007). Rather, the highest amplitude should be picked irrespective of period, or at a distance-dependent period as in Willmore (1979).

For larger events, it is likely that the largest amplitudes will be at 20 s anyway, but smaller earthquakes, such as those in NW Europe, are (for obvious reasons) not effective producers of 20 s surface waves, and the maximum amplitude will have a lower period. The effect is that continuing to pick amplitudes at 20 s irrespective of the size of the event progressively underestimates the M_S value as magnitude decreases. Since the practice at the National Earthquake Information Centre (NEIC) in the US has been to pick amplitudes only between 18 and 22 s, the vast majority of M_S values to be found in global databases show a pronounced roll-off in M_S values compared to M_W at low magnitudes, and this affects the shape of the conversion formulae cited above.

However, most, if not all, M_S values published for NW Europe derive directly or indirectly from the work of Ambraseys (e.g. Ambraseys 1985, 1988), who did not use the 20 s limitation. Although the Arup (1993) catalogue is largely

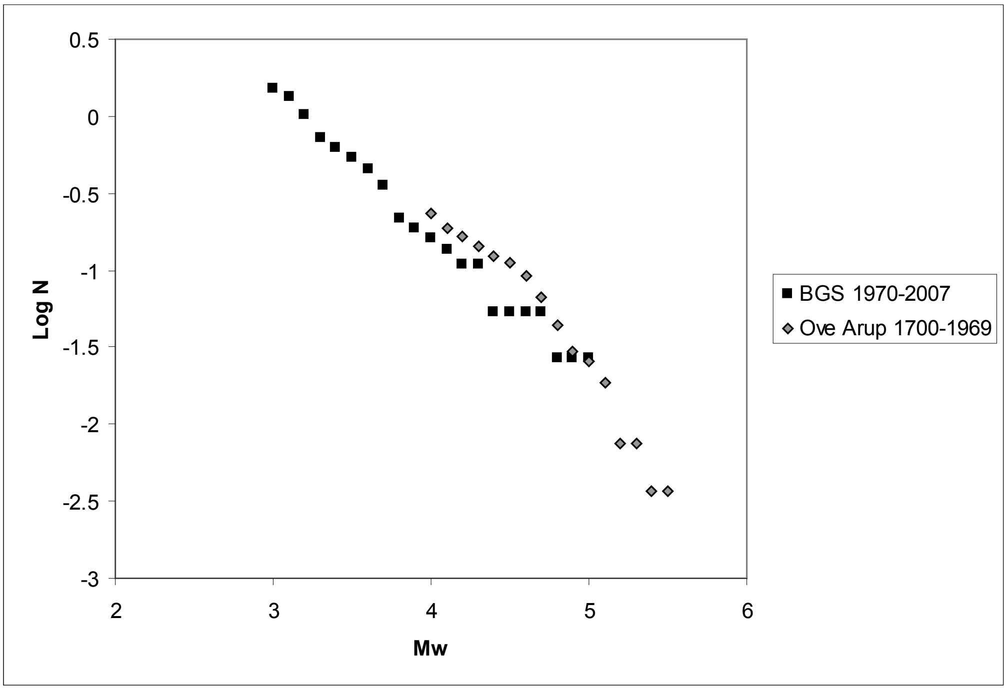

Figure 2. Revised comparison using updated M_S to M_W conversion

composed of M_S values estimated from macroseismic data, these M_S values are calibrated against instrumental M_S values not calculated at 20 s.

Consequently, M_S-M_W conversion formulae based on NEIC or similar M_S values cannot be applied reliably to the Arup (1993) catalogue, which implicitly uses a different definition of M_S magnitude. Confusingly, these two versions are seldom distinguished in the literature; the current IASPEI working group on magnitudes has proposed the notation $M_S(20)$ and $M_S(BB)$ to distinguish the two, where "BB" stands for "broadband" (Bormann et al 2009).

So it is not surprising that it was found by Bungum et al (2003), and confirmed by Grünthal et al (2003) and subsequently by Grünthal et al (2009), that published M_S-M_W formulae do not give good results for NW Europe. These references agree that the relationship between the two scales for this region is approximately equality. There are very few UK events with both M_S and M_W instrumental determinations, but those that do exist show M_W to be equal or slightly smaller than M_S, whereas the EPRI (1994) relation should show M_W consistently larger than M_S, by +0.7 units at 4.0 M_S, down to +0.1 units for 5.5 M_S (the largest UK event).

If one now converts Arup (1993) to M_W using Bungum et al's (2003) conversion, the result is Figure 2. And now it is apparent that the two data sets are consistent within acceptable margins.

The consequences of using the EPRI (1994) conversion in UK hazard analysis are marked. Given that seismic hazard in the UK is dominated by smaller, frequent events rather than rare large ones (Musson 2000), quadrupling the frequency of 4.7 M_W events is evidently going to raise the hazard significantly, depending partly on how sensitive the ground motion model is to magnitude scaling. This issue never arose in Musson and Sargeant (2007), where M_S was never used, and the entire catalogue was converted from M_L to M_W in a consistent way. This is the main reason why, for instance, for PGA at an annual frequency of 0.0004, Lubkowski et al (2010) obtain 0.14 g for Carlisle, whereas Musson and Sargeant (2007) give 0.04 g.

One can also note the magnitude-frequency plot in Lubkowski et al (2010)'s Figure 2, which predicts an earthquake of 4.2 M_W (about 4.5 M_L) on average once per year in the UK. Even a quick glance at the UK seismic record shows that this is not compatible with recent history, a clear warning sign that something is amiss.

It is likely that, with the Arup (1993) catalogue updated as in Figure 2, the recomputed hazard would be much closer to the results of Musson and Sargeant (2007), bearing in mind that the Arup (1993) source model tends to even out hazard over the whole country.

PSHA results are often sensitive to apparently innocuous decisions in unexpected ways, and it points out the need for careful scrutiny at all stages of a study. Resolving differences between studies is a useful exercise in identifying and understanding the underlying factors that influence results.

Acknowledgements

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Manual for the seismic design of steel and concrete buildings to Eurocode 8

This Manual, published by IStrutE, supports the seismic design of buildings to BS EN 1998-1: 2004 and BS EN 1998-5: 2004 and their National Annexes. It covers fully the seismic aspects of the design of steel and concrete buildings up to 40m high which do not have significant structural irregularity. However, the Manual may also be useful for the seismic design of taller or more unusual structures.

SECED members can purchase the Manual at the discounted price of £70 (full price £100). This offer is open for three months, closing on 25th January 2011. To obtain the discount, enter the code *SECED* at the checkout point when prompted.
The book may be purchased at the following address:
http://shop.istructe.org/manual-for-the-seismic-design-of-steel-and-concrete-buildings-to-eurocode-8.html

Notable Earthquakes January – March 2010

Reported by British Geological Survey

Issued by: Davie Galloway, British Geological Survey, January 2010.
Non British Earthquake Data supplied by The United States Geological Survey.

			Time			Dep	Magnitude			
Year	Day	Mon	UTC	Lat	Lon	km	M_L	M_b	M_W	Location
2010	01	APR	10:14	61.88N	3.49E	10	3.3			NORTHERN NORTH SEA
2010	04	APR	22:40	32.30N	115.28W	4			7.2	BAJA CALIFORNIA, MEXICO
Two people killed, at least 233 injured and hundreds of buildings damaged in the Mexicali, Calexico and Imperial areas. Some surface faulting (around 28 km) observed on the Borrego Fault, southwest of Mexicali.										
2010	06	APR	22:15	2.38N	97.05E	31			7.8	NTH SUMATRA, INDONESIA
2010	11	APR	09:40	10.88S	161.12E	21			6.8	SOLOMON ISLANDS
2010	13	APR	23:49	33.17N	96.55E	17			6.9	SOUTH QINGHIA, CHINA
At least 2,220 people killed (and 70 still reported missing), over 12,000 injured and many buildings damaged or destroyed in Yushu County.										
2010	18	APR	20:28	35.67N	67.66E	10			5.6	CENTRAL AFGHANISTAN
Eleven people killed, over 70 injured and at least 2,000 houses damaged in the epicentral region.										
2010	21	APR	06:08	53.26N	1.20W	1	1.7			WORKSOP, NOTTS
Felt Edwinstowe (3 EMS).										
2010	26	APR	02:59	22.18N	123.73E	21			6.5	SOUTHEAST OF TAIWAN
2010	30	APR	23:11	60.51N	177.90W	17			6.5	BERING SEA
2010	01	MAY	20:01	54.32N	2.46W	8	1.9			SEDBERGH, CUMBRIA
2010	03	MAY	23:07	54.11N	2.52W	9	1.8			BENTHAM, N YORKSHIRE
2010	05	MAY	16:29	4.06S	102.00E	27			6.6	STH SUMATRA, INDONESIA
2010	06	MAY	02:42	18.06S	70.55W	37			6.2	OFF TARAPACA, CHILE
Eleven people injured and some buildings slightly damaged in the Tacna area, Peru.										
2010	06	MAY	22:24	52.85N	9.36W	5	2.7			CO. CLARE, IRELAND
Felt County Clare (3 EMS).										
2010	07	MAY	00:15	54.35N	1.73W	7	1.8			RICHMOND, N YORKSHIRE
2010	09	MAY	05:59	3.75N	96.03E	45			7.2	NTH SUMATRA, INDONESIA
Slight damage and a power outage reported on Simeulue Island.										
2010	14	MAY	12:29	36.00N	4.16E	10		5.2		NORTHERN ALGERIA
Two people killed and 43 others injured near Beni Yellman.										
2010	24	MAY	16:18	8.08S	71.55W	583			6.5	ACRE, BRAZIL
2010	26	MAY	08:53	25.79N	129.94E	10			6.5	SE RYUKYU ISLANDS
2010	27	MAY	17:14	13.67S	166.58E	31			7.1	VANUATU
2010	29	MAY	16:50	55.94N	4.39W	4	1.9			CLYDEBANK, STRATHCLYDE
2010	31	MAY	19:51	11.09N	93.52E	105			6.5	ANDAMAN ISLANDS, INDIA
2010	07	JUN	16:06	59.12N	1.98E	18	2.7			NORTHERN NORTH SEA
2010	07	JUN	17:33	55.11N	3.62W	8	2.3			DUMFRIES, D & G
Felt Dumfries (3 EMS).										
2010	12	JUN	19:26	7.85N	91.92E	35			7.5	NICOBAR ISLANDS, INDIA
2010	16	JUN	03:16	2.17S	136.55E	18			7.0	PAPUA, INDONESIA
At least seventeen people killed and over 2,500 buildings damaged or destroyed on Yapen and Biak leaving around 10,000 people displaced.										

Year	Day	Mon	Time UTC	Lat	Lon	Dep km	Magnitude M_L	M_b	M_W	Location
2010	16	JUN	03:58	2.33S	136.48E	11			6.6	PAPUA, INDONESIA
2010	19	JUN	10:17	53.43N	0.67W	10	2.7			GAINSBOROUGH, LINCS
2010	21	JUN	05:02	52.49N	1.70W	10	2.3			BIRMINGHAM, W MIDLANDS
2010	26	JUN	05:30	10.63S	161.45E	35			6.7	SOLOMON ISLANDS
2010	28	JUN	20:34	53.51N	0.64W	9	1.9			SCUNTHORPE, N LINCS
2010	30	JUN	00:35	53.59N	1.04W	3	2.0			DONCASTER, S YORKSHIRE
Felt Doncaster (4 EMS).										

New Editor for the SECED Newsletter

After nearly three years as Editor of the SECED Newsletter, Mr A Nielsen has announced his intention to stand down as soon as a suitable replacement has been appointed. Anyone interested in taking over the reins should register his or her interest with the current Chairman of the Society, Professor Ahmed Elghazouli (a.elghazouli@imperial.ac.uk).

The successful applicant will be required to produce up to four Newsletters per year (depending on the amount of contributions), using an appropriate desktop publishing software package (Adobe InDesign will be supplied).

The benefits of the role include:

- A co-opted seat on the SECED Committee.
- Continuous Professional Development through service to a learned society.
- Lifetime honorary membership of SECED after minimum three years of service.
- Keeping up to date with the latest events, ideas and developments in the UK and abroad.

For further information regarding this role, please contact Andreas Nielsen (andreas.nielsen@jacobs.com).

SECED Newsletter

The SECED Newsletter is published quarterly. Contributions are welcome and manuscripts should be sent on a CD or by email. Diagrams, pictures and text should be in separate electronic files. Copy typed on paper is also acceptable. Diagrams should be sharply defined and prepared in a form suitable for direct reproduction. Photographs should be high quality. Colour images are welcome. Diagrams and photographs are only returned to authors on request.

Contributions should be sent to the Editor of the Newsletter, Andreas Nielsen.

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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 Geological 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. For further information about SECED contact:

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Or visit the SECED website:
http://www.seced.org.uk

Forthcoming events

Date	Venue	Title	People
08/12/2010 at 18:00	Imperial College London South Kensington Campus (Lecture Theatre 201)	*Evolving seismic design from ensuring life safety to achieving high seismic performance*	*Speaker*: **Prof Constantin Christopoulos** (University Of Toronto, Canada) *Organiser*: **Damian Grant** (University College London)
26/01/2010 at 18:00	ICE One Great George Street Westminster London	*Earthquakes, volcanoes and God: theological perspectives on natural disaster* (see synopsis below)	*Speaker*: **Rev Dr David K. Chester** (University of Liverpool) *Organiser*: **Julian Bommer** (Imperial College London)

For up-to-date details of SECED events, visit the website: **www.seced.org.uk**

Evening meeting on 26 January

Earthquakes, volcanoes and God: theological perspectives on natural disaster – Synopsis

The Hebrew and Christian scriptures usually interpret disasters in terms of divine wrath visited on sinful people and nations, but discussion of catastrophes did not end at the close of the biblical era and continued throughout Christian history, with a number of alternative models being developed, some of which only became prominent following the devastation wrought by the Lisbon earthquake in 1755.

In the past few decades there has been a sea-change in both Christian attitudes towards disasters and in the ways in which losses are viewed by hazard researchers. From the perspective of the latter, an approach that envisions disasters as being primarily caused by extreme physical events has been largely replaced by one in which disasters are studied as social constructs, with emphasis being placed on human vulnerability. From the perspective of Christian theology much reflection on disasters, especially on earthquakes which have occurred in South America, has resulted in greater prominence now being given to viewing disasters as events that represent institutional rather than individual human sinfulness, and which is manifested in national and international disparities in wealth, poverty, hazard preparedness and disaster losses.

Greater focus is also placed on Christian praxis, rather than merely trying to understand the nature of supposed divine responsibility. It is argued that these new hazard analytical and theological perspectives are synergetic: allowing on the one hand churches, their members as well as their leaders, more fully to engage in disaster relief; whilst, on the other, enabling civil defence planners more effectively to use the often considerable human and financial resources of Christian communities and their charitable agencies.

David K Chester

David K Chester obtained his PhD from the University of Aberdeen in 1978 and is currently Reader in the Department of Geography at the University of Liverpool. His research is primarily focused on natural hazards, including volcanoes, earthquakes and landslides, as well as geomorphology. In 1996, David obtained his Diploma of Theology from the University of Liverpool and he is an ordained minister of the Church of England. In this presentation, he brings together his academic and theological interests, as he has done in several of publications.

The Destruction of Sodom and Gomorrah
John Martin (1852)