ISSN 0967-859X
THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

NEWSLETTER

Volume 29 No 2
July 2018

In this issue

Response of Earth Dams to Earthquake Events – Field Data and Numerical Modelling

Loizos Pelecanos
Department of Architecture & Civil Engineering
University of Bath, UK

Stavroula Kontoe, Lidija Zdravković
Department of Civil & Environmental Engineering
Imperial College London, UK

Abstract

This paper is the written version of the SECED evening talk given at the ICE by the first author on 29 November 2017. It presents numerical analyses related to the seismic response of earth dams. A well-documented case study is considered, the La Villita earth dam in Mexico, for which relevant useful field data are available. The developed numerical model was able to simulate very well the recorded dam response under seismic loading and was used as a basis for a subsequent parametric investigation. Issues related to the stiffening effect of the narrow canyon, dam–reservoir interaction and dam–foundation interaction are discussed.

Introduction

Many earth dams around the world are located in zones characterised by moderate to high seismicity. Their seismic stability can be particularly critical for the safety of the areas in the downstream side and therefore an in-depth understanding of their response during earthquakes is required. Relevant experimental data are hard to obtain, as full-scale tests are very expensive to perform and real data recorded from actual earthquakes are rare and sparse. On the other hand, sophisticated numerical models do exist nowadays, but they need to be calibrated against real measurements from previous earthquake events before they are used reliably for future design.

This paper presents the seismic response of the La Villita Dam in Mexico under two different earthquake events of distinct intensity. Analysis of the actual field data along with relevant static and dynamic nonlinear finite element (FE) analyses are presented and discussed to obtain an understanding of the behaviour of the dam. Such a validation is necessary to build confidence in the developed numerical models. Subsequently, several issues related to the general performance of dams during an earthquake are discussed, such as the stiffening effect of narrow canyon topography, dam–reservoir interaction (DRI) and the effect of the compliant dam foundation.

Case study: La Villita earth dam, Mexico

La Villita is a 60 m high zoned earth dam in Mexico, founded on a 70 m thick alluvium layer and built in 1967. The dam is composed of a central clay core, sand filters and rockfill shells. It has experienced a number of seismic events (among which the most significant was the M_s 8.1 Michoacán earthquake on 19 September 1985) sustaining some permanent deformations and crest settlements. Relevant details may be found in papers by Elgamal (1992) and Pelecanos (2013).

Pelecanos et al. (2015) performed two-dimensional (2D) plane-strain static and dynamic coupled-consolidation FE analyses (cross-sectional geometry shown in Figure 1), employing the Imperial College Finite Element Program (ICFEP) (Potts and Zdravković, 1999; 2001; Kontoe, 2006). The full static stress history of the dam prior to the earthquake events (construction, reservoir impoundment and consolidation) was modelled prior to the dynamic analyses. The material constitutive model was a cyclic nonlinear elastic model which dictates the degradation of shear stiffness, G, and the increase of damping, ξ, with cyclic shear strain, γ, coupled with a Mohr–Coulomb yield criterion. The material properties were obtained from Elgamal (1992).

Figures 2a and 2b show a comparison of the response spectra derived from the numerical predictions of acceleration response at the crest of the dam during the 15/11/1975 and 19/9/1985 seismic events respectively, with those derived from the corresponding filtered recorded motions. The stiffening effect of the narrow canyon geometry was accommodated in a 2D plane-strain analysis by using an appropriate ‘increased’ value of the shear modulus, G, which was in accordance with the suggestions of Dakoulas and Gazetas (1987) for dams built in narrow canyons. Moreover, due to the possible existence of a localised slip failure close to the monitoring instrument at the crest (Elgamal, 1992; Pelecanos et al., 2015), the high frequencies of the recorded motion that corresponded to strike-slip failure were filtered. In general, Figure 2 shows that the developed numerical model was able to capture the response under both seismic events (of different magnitude, duration and frequency content) very well. It should be noted that the same set of soil properties and constitutive model parameters were used for both excitations.

Dam–reservoir interaction

In static conditions, the upstream reservoir induces hydrostatic pressures on the upstream face of an earth dam. Under seismic conditions, additional hydrodynamic pressures develop affecting the vibration of the dam which interacts with the vibration of the reservoir. The critical question is whether DRI effects are significant for concrete and earth dams.

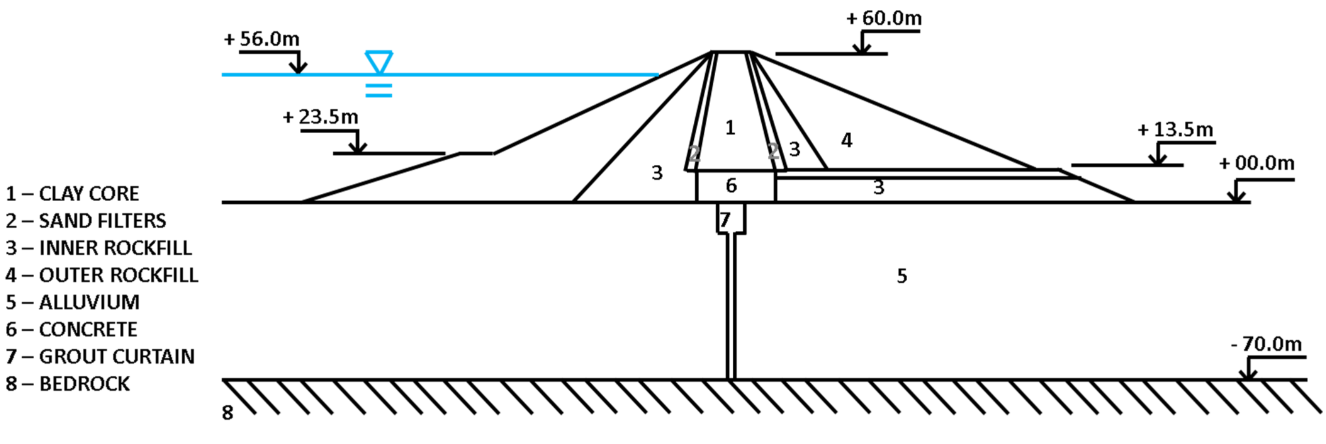


Figure 1: La Villita earth dam (Pelecanos, 2013).

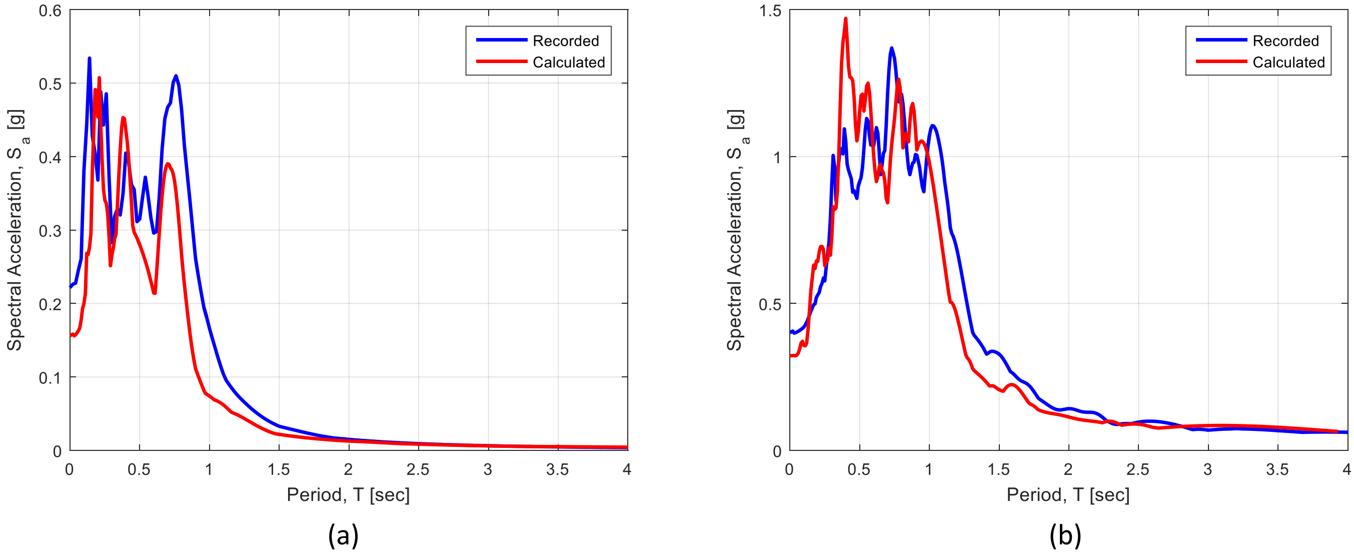


Figure 2: Seismic response of the dam – comparison of response spectra derived from recorded and calculated accelerations: (a) 15/11/1975 earthquake; (b) 19/9/1985 earthquake.

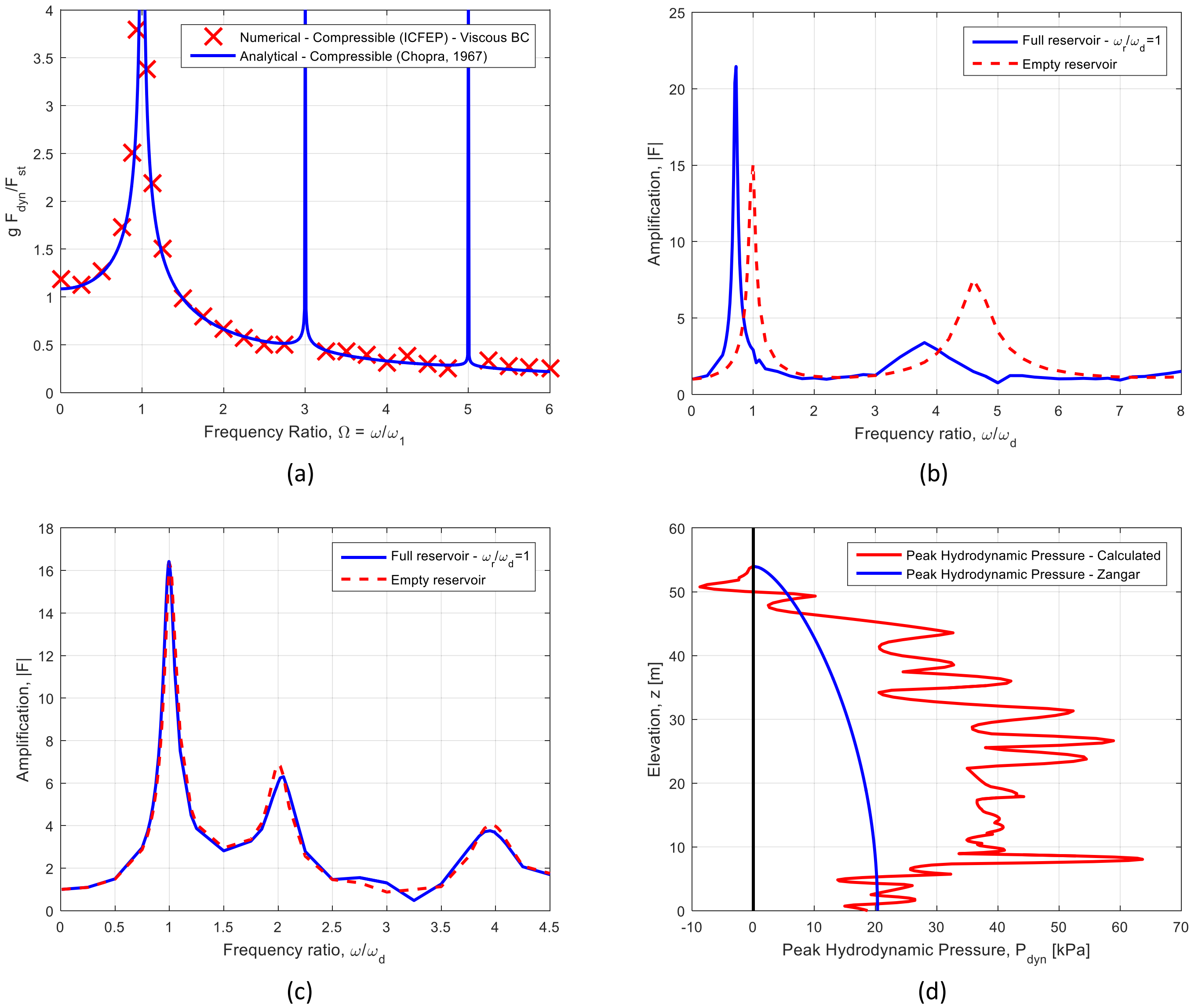


Figure 3: DRI: (a) Verification of numerical modelling (Pelecanos et al., 2013); (b) amplification of accelerations for concrete dams (Pelecanos et al., 2016), (c) amplification of accelerations for earth dams (Pelecanos et al., 2016); (d) transient hydrodynamic pressures (Pelecanos et al., 2018a).

Firstly, one needs to model in an appropriate way the hydrodynamic pressures by discretising the reservoir domain. A methodology was proposed by Pelecanos et al. (2013) in which the reservoir is modelled with elastic solid continuum elements having the bulk modulus of water (K_w = 2.2 GPa; i.e., compressible) and a small value of G. Interface elements can be placed between the reservoir and the dam/foundation domains with high normal and small shear stiffness, while the Viscous or Cone boundary conditions (BCs) can be employed at the upstream truncated boundary. Extensive validation was carried out by Pelecanos et al. (2013) for various loading conditions and Figure 3a shows a comparison of the numerical predictions against the analytical closed-form solution of Chopra (1967) regarding the dynamic pressures spectrum. The latter figure plots the ratio of the total hydrodynamic force, F_{dyn}, multiplied by the acceleration of gravity, g, over the hydrostatic force, F_{st}, on the upstream face of a model dam, against various values of the ratio, Ω, of the circular frequency of the excitation, ω, over the fundamental circular frequency of the reservoir, ω_1.

Pelecanos et al. (2016) studied the visco-elastic dynamic DRI response of model concrete and earth dams and found that DRI affects both (i) the amplification of accelerations and (ii) the natural frequency of vibration of dams. The effects are more pronounced for concrete dams, as shown in Figures 3b and 3c. The latter figures plot the amplification of accelerations, $|F|$, at the dam crest with respect to the ratio of ω over the fundamental circular frequency of the dam, ω_d.

Nonlinear transient dynamic FE analysis of La Villita Dam was performed by Pelecanos et al. (2018a) with a discretised reservoir calculating the reservoir hydrodynamic pressures. Figure 3d plots the calculated profile of maximum hydrodynamic pressures, P_{dyn}, on the upstream face of the dam during the 19/9/1985 Mexico earthquake, and compares that to the analytical solution of Zangar (1952). The latter solution underestimates significantly the hydrodynamic pressures due to the adopted assumptions of incompressible reservoir and rigid dam.

Dam–foundation interaction

Pelecanos et al. (2018b) examined the seismic response of La Villita Dam (which is built on a compliant foundation layer) as if it was built on a rigid foundation. Two approaches were followed; (i) using the bedrock motion directly as an input, and (ii) performing first a site response analysis of the foundation layer to obtain the ground surface response and using this as an input to the analysis of the dam built on a rigid foundation.

Figure 4 plots the response spectra of the calculated accelerations at the dam crest, and compares them to the response spectrum corresponding to the case of the full dam–foundation system. The two attempts to decouple the dam–foundation interaction predicted significantly higher values of spectral accelerations, which is rather conservative, and therefore the above approaches are not recommended for use in practice. Instead, it is suggested that dam–foundation systems are modelled in a monolithic way as in Pelecanos et al. (2015).

Conclusions

This paper presents a series of nonlinear FE analyses related to the seismic response of earth dams. A well-documented earth dam, the La Villita earth dam in Mexico, for which available useful field data are available, was used as a case study. The findings of this study may be summarised as follows:

- Earth dams can be significantly affected by earthquakes and may sustain considerable settlements, deformations and slope instability.
- Dams built in narrow canyons exhibit a stiffer response than dams built in wide canyons, and therefore a full three-dimensional numerical analysis is required in the former case. However, a 2D plane-strain analysis with an increased value of material stiffness is

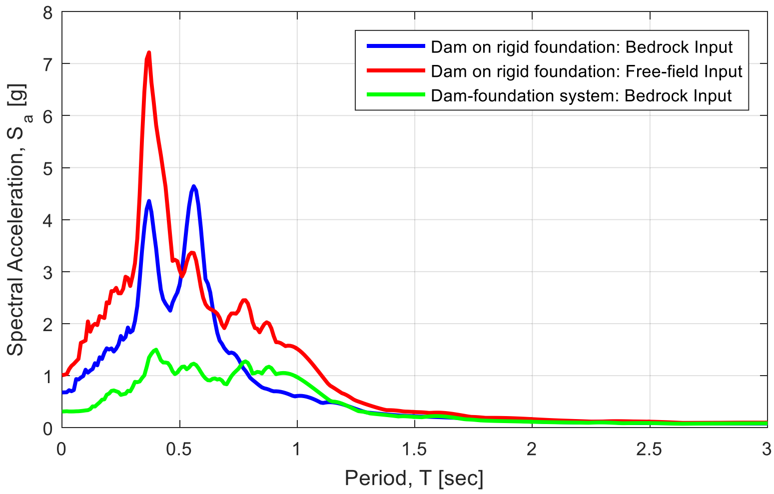


Figure 4. Response spectra at the crest of the dam for different modelling approaches of dam–foundation interaction (Pelecanos et al., 2018b).

computationally more efficient and a reasonable compromise.

- The reservoir domain may be modelled with elastic solid compressible finite elements. The Viscous or Cone BCs may be used at the upstream truncated boundary.
- Dam–reservoir interaction affects both the amplification and the frequency content of dam accelerations. It is found to have a larger effect on concrete dams than earth dams. The analytical relation of Zangar (1952) appears to under-predict the hydrodynamic pressures.
- Dam–foundation interaction affects the seismic response of earth dams. The foundation soil should not be ignored in an analysis; instead a dam–foundation system should be modelled in a monolithic way.

Acknowledgements

The work presented is part of the PhD study of the first author at Imperial College (2009–2013), supervised by the other authors and funded by EPSRC. This contribution is gratefully acknowledged.

References

Chopra, A. K. (1967). Hydrodynamic pressures on dams during earthquakes. *ASCE Engineering Mechanics*, **93:** 205–223.

Dakoulas, P., & Gazetas, G. (1987). Vibration characteristics of dams in narrow canyons. *ASCE Journal of Geotechnical Engineering*, **113:** 899–904.

Elgamal, A. W. (1992). Three-dimensional seismic analysis of La Villita Dam. *ASCE Journal of Geotechnical Engineering*, **118:** 1937–1958.

Kontoe, S. (2006). *Development of Time Integration Schemes and Advanced Boundary Conditions for Dynamic Geotechnical Analysis*. PhD Thesis, Imperial College London.

Pelecanos, L. (2013). *Seismic Response and Analysis of Earth Dams*. PhD Thesis, Imperial College London.

Pelecanos, L., Kontoe, S., & Zdravković, L. (2013). Numerical modelling of hydrodynamic pressures on dams. *Computers and Geotechnics*, **53:** 68–82.

Pelecanos, L., Kontoe, S., & Zdravković, L. (2015). A case study on the seismic performance of earth dams. *Géotechnique*, **65:** 923–935.

Pelecanos, L., Kontoe, S., & Zdravković, L. (2016). Dam–reservoir interaction effects on the elastic dynamic response of concrete and earth dams. *Soil Dynamics and Earthquake Engineering*, **82:** 138–141.

Pelecanos, L., Kontoe, S., & Zdravković, L. (2018a). The effects of dam–reservoir interaction on the nonlinear seismic response of earth dams. *Journal of Earthquake Engineering*. Available at: https://www.tandfonline.com/doi/full/10.1080/13632469.2018.1453409.

Pelecanos, L., Kontoe, S., & Zdravković, L. (2018b). Nonlinear seismic response of earth dams and dam–foundation interaction [In preparation].

Potts, D. M., & Zdravković, L. (1999). *Finite Element Analysis in Geotechnical Engineering: Theory*, Thomas Telford Ltd, London.

Potts, D. M., & Zdravković, L. (2001). *Finite Element Analysis in Geotechnical Engineering: Application*, Thomas Telford Ltd, London.

Zangar, C. N. (1952). Hydrodynamic Pressures on Dams due to Horizontal Earthquake Effects. *Engineering Monograph No. 11*, U.S. Bureau of Reclamation.

SECED Newsletter

The SECED Newsletter is published quarterly. All contributions of relevance to the members of the Society are welcome.

Manuscripts should be sent by email. Diagrams, pictures and text should be attached in separate electronic files. Hand-drawn diagrams should be scanned in high resolution so as to be suitable for digital reproduction. Photographs should likewise be submitted in high resolution. Colour images are welcome.

Please contact the Editor of the Newsletter, Damian Grant, for further details: damian.grant@arup.com.

This edition of the Newsletter was co-edited by Konstantinos Gkatzogias (konstantinos.gkatzogias.1@city.ac.uk).

Editors' note: On 27th September 2017, Alex Shepherd (WYG) and Euan Stoddart (MMI Engineering), both members of the SECED Young Members' Subcommittee, presented their work during the SECED meeting in Warrington. Their talks form part of the SECED Young Members' Group 'Snapshot intitiative', where young members deliver short presentations prior to the main evening lecture. The following articles are summaries of their presentations.

'Building Back Better' since the 2015 North Gorkha Earthquake

Alex Shepherd
WYG, Chorley

In April 2015 the Gorkha district of Nepal was hit by a M_w 7.8 earthquake; this was then followed by a major aftershock which occurred close to the city of Kathmandu in May that year. The events caused widespread damage across the region leading to 9,000 fatalities, over 500,000 homes lost and a significant amount of key infrastructure being critically damaged or destroyed.

WYG became involved with the UK-based charity 'Community Action Nepal' (CAN), following a call for help made via the British Expertise Organisation. The charity was founded by the famous British mountaineer Doug Scott CBE, and works to improve the living and working conditions of the indigenous mountain people of Nepal.

Since June 2015, WYG have been providing pro bono technical support to CAN for the reconstruction of their 30 health posts, schools and other key infrastructure in the remote Himalayan regions of Nepal (Figure 1). Initially deploying project management, geotechnical and engineering specialists in Nepal to carry out damage assessments and develop an achievable rebuild programme, WYG integrated team members into CAN to develop and strengthen their in-house construction team. WYG have since taken on a governance role as programme managers, sharing methods and experience from projects in other fragile and conflict-affected states with the Nepalese team.

In December 2017, WYG made their sixth and final construction progress visit to Nepal since 2015, in order to assess the final stages of the 'building back better' campaign before all sites were formally reopened in May 2018 (Figure 2). Throughout the visit, WYG and CAN representatives reviewed the progress of construction projects in Helambu, Solu Khumbu, Langtang, North Gorkha, Tsum Valley and Bahrabise. CAN projects are predominantly built of dry stone masonry and designed to government standards. Projects are also in line with CAN's Construction Ethos which was produced as a guiding document for the

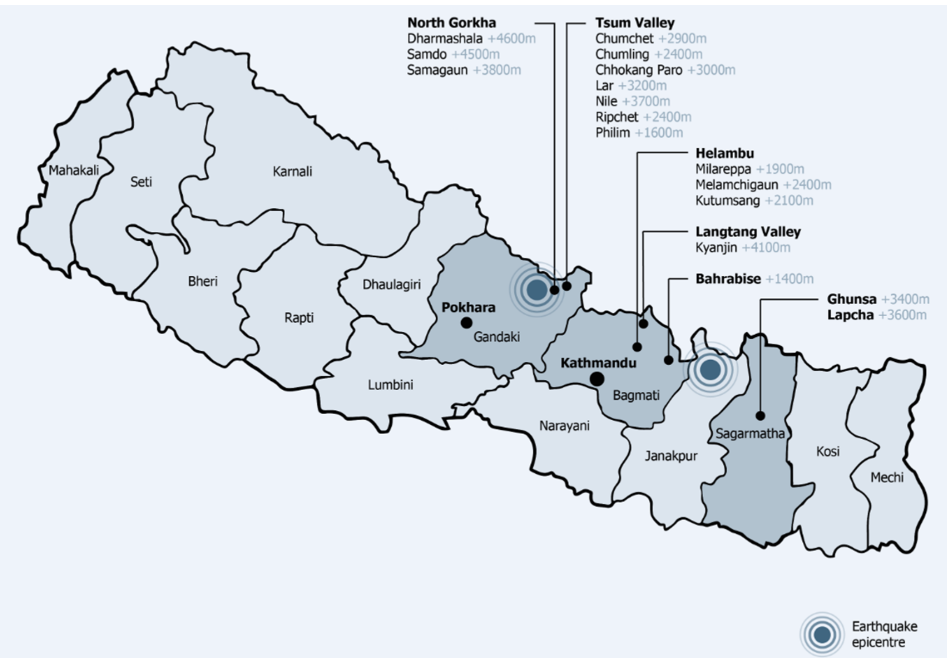


Figure 1: Geographic spread of CAN projects damaged in the 2015 earthquake.

Figure 2: 2017 WYG/CAN team in Tsum Valley.

'building back better' campaign, setting out the charities' approach to investment in the region and the expectations for improving the quality of buildings within their funding projects. This approach has significantly raised the standards of the rebuild programme and engendered a 'capacity building' approach within the local communities with the aim of reducing the reliance on donor funding and support going forward.

Although CAN/WYG have seen significant improvement during this rebuilding programme, serious concerns have been highlighted on other rebuilding projects in the region, despite being funded by other International Non-Governmental Organisations (INGOs). This issue was of such concern to the team that an article was submitted to the Kathmandu Post (Buchan, 2018) to raise awareness of the evident lack of engagement with construction experts in the post-disaster reconstruction. Part of the article is reproduced in the following;

> *We have frequently seen evidence of attempts to include seismic-resilient building techniques into stone buildings in rural areas; however, the quality of workmanship renders most techniques ineffective. Common failures include missing or poorly connected ring beams and poor roof construction. In Nepal, as well as in other seismic regions, poor quality workmanship is the primary pitfall that compromises the safety of new or repaired buildings. When this happens, the efforts of the design stage are undermined and ineffective, whether construction experts have been engaged or not. Employing – or engaging pro bono services – of a construction expert during the construction stage of a project can help ensure such common mistakes are avoided or identified in time to allow them to be rectified if necessary.*
>
> *The presence of experts during construction is therefore the area where construction experts can be most valuable, but is also where many INGOs fail in their delivery of safe buildings. Ideally, construction experts should be from the local area so any potential language and cultural barriers can be minimised. If not, they should be embedded into the local community and culture, and have the confidence to stand up to builders to make sure that corners aren't cut and quality standards are met.*
>
> *International experts can also be engaged where there is a lack of local or national expertise, or to provide guidance and assurance to less experienced local professionals in a particular building method or in seismic-resilience in general. However, international experts must be pragmatic in their approach to assessing quality of construction and they must have an appreciation of the nuances of the local culture and politics, and their potential implications on a project. INGOs must also be mindful that international experts support local professionals and builders, not replace them.*

Acknowledgements

The author would like to thank all the team at Community Action Nepal for their tireless efforts during the 'building back better' campaign in both fundraising and project delivery. Also, many thanks to WYG for funding the cost of WYG's involvement to date and all the WYG team members for volunteering their time and continued effort.

References

Buchan, C. (2018). Experts know best. *The Kathmandu Post*. [Online] 2nd February. Available at: http://kathmandupost.ekantipur.com/news/2018-02-19/experts-know-best.html.

Explosion Pressure Relief – Design and Testing

Euan Stoddart
MMI Engineering Ltd, Warrington

Numerical modelling and experimental testing were used to investigate the potential explosive overpressures on existing gas-filling houses. The calculated demand was used to determine whether the buildings had sufficient resistance or needed to be rebuilt at a huge cost to the client. This summary outlines the background to the threat, the methodology undertaken and the results of the study.

The filling of domestic aerosols with liquefied petroleum gas (LPG) propellants (propane/butane blends) involves an inherent explosion hazard and is therefore typically carried out in unmanned buildings external to the main factories. Due to the hazard, there is a requirement for operators to demonstrate that appropriate measures are in place either to prevent explosions from occurring or to protect against/minimise their effects.

Explosion prevention is always preferable to explosion protection and is achieved by providing gas detection, forced ventilation and automatic shutdown. Additional safety measures include classifying the gas house as a hazardous area and performing unmanned operation. However, the risk remains for these barriers to fail or for the gas release to be of such size that a significant explosion could occur potentially leading to catastrophic failure of the gas house building. Venting is often provided to relieve the associated pressure and limit the loads acting on the structure. The required venting area can be calculated by using simplistic methods such as those defined in the 'NFPA 68' standard (National Fire Protection Association, 2018) or by more detailed assessments employing computational fluid dynamics (CFD).

This research study investigated the behaviour of gas houses subjected to internal explosion through experimental testing and numerical modelling. The gas house design was cylindrical (cylindrical shape is often used due to better ventilation) with venting provided through the use of a lifting roof structure as employed at a number of facilities worldwide. A purpose-built full-scale steel rig was designed and fabricated (Figure 1) to allow repeatable tests to be performed using a polythene-sheet roof (providing the lower bound overpressure) and multiple alternative roof designs. A number of parameters were considered, including ignition location, level of ventilation and congestion, to investigate the sensitivity of results. Numerical modelling was performed using FLACS (Gexcon, 2016) which is a well-established CFD code that was developed to model explosions; FLACS has been used extensively in support of the 'Control of Major Accident Hazards' (COMAH) and 'Offshore Installations (Safety Case)' regulations (http://www.hse.gov.uk), and it has been subjected to extensive validation (Lea and Ledin, 2002; Gant and Hoyes, 2010).

Although the lifting roof employed metal chains to limit displacements, during testing the chains failed trigerring an uncontrolled and potentially hazardous behaviour (Figure 2). The failure was attributed to the sudden restraint at the chain limit which induced shock-type loads on the roof structure resulting in weld and connection failures. This is a highly dynamic problem and alternative designs,

Figure 1: Full scale experimental test rig.

Figure 2: Experimental testing of lifting roof design.

potentially including the use of dampers or frangible panels, are currently under investigation.

The results indicated that the internal overpressures obtained from the numerical modelling were significantly higher than those from the experimental programme. The lower demands in the latter case were used to justify limited retrofits of existing gas house walls with significant cost savings compared to reconstruction. It was concluded that whilst FLACS was developed for the offshore industry, typically with high levels of congestion, it is less suited to more open geometries of this nature and care should be taken when using it outside its sphere of validation. Following discussions with the software authors, a new version of the combustion solver is currently in development and the data from the experimental programme will be used to validate and extend the range of applicability in the future.

References

Gant, S., & Hoyes, J. (2010). Review of FLACS Version 9.0 – Dispersion Modelling Capabilities. *Research Report 779*, Health and Safety Laboratory, Buxton, UK.

Gexcon (2016). *FLACS – Flame Acceleration Simulation*. Gexcon AS, Bergen, Norway.

Lea, C. J., & Ledin, H. S. (2002). A Review of the State-of-the-Art in Gas Explosion Modelling. *Report No. HSL/2002/02*, Fire and Explosion Group, Health and Safety Laboratory, Buxton, UK.

National Fire Protection Association (2018). *NFPA 68: Standard on Explosion Protection by Deflagration Venting*. National Fire Protection Association, Massachusetts, USA. Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=68 [accessed in January 2018].

Notable Earthquakes January 2018 – April 2018

Reported by British Geological Survey

Issued by: Davie Galloway, British Geological Survey, May 2018.
Non British Earthquake Data supplied by: United States Geological Survey.

Year	Day	Mon	Time UTC	Lat	Lon	Dep km	Magnitude ML	Mb	Mw	Location
2018	10	JAN	02:51	17.48N	83.52W	19			7.5	CARIBBEAN SEA
Several homes damaged in Atlántida, Olancho and Islas de la Bahia, Honduras. A small tsunami was recorded in the Cayman Islands.										
2018	14	JAN	09:18	15.77S	74.71W	39			7.1	SOUTHERN PERU
Two people killed, at least 65 others injured and widespread damage occurred throughout the region.										
2018	18	JAN	16:15	49.93N	4.37W	7	1.7			ENGLISH CHANNEL
2018	23	JAN	09:31	56.00N	149.17W	14			7.9	GULF OF ALASKA
2018	27	JAN	21:11	56.40N	5.72W	6	1.2			MULL, ARGYLL & BUTE
Felt Croggan (2 EMS).										
2018	28	JAN	16:03	53.06S	9.68E	10			6.6	SOUTH ATLANTIC OCEAN
2018	28	JAN	17:10	56.40N	5.67W	6	1.6			MULL, ARGYLL & BUTE
Felt Croggan (2 EMS).										
2018	31	JAN	07:07	35.53N	70.85E	193			6.2	HINDU KUSH, AFGHANISTAN
One person killed in Swat and two others injured in Landi Arbab, Pakistan.										
2018	05	FEB	15:32	57.06N	5.74W	7	1.8			KNOYDART, HIGHLAND
2018	06	FEB	15:50	24.13N	121.66E	17			6.4	TAIWAN
At least 17 people killed (some still reported as missing), over 285 others injured and many buildings collapsed in Hualien City.										
2018	10	FEB	12:28	52.40N	2.88W	8	1.5			CLUNGUNFORD, SALOP
2018	16	FEB	06:48	53.85N	3.66W	3	2.2			IRISH SEA
2018	16	FEB	23:39	16.42N	97.96W	22			7.2	OAXACA, MEXICO
Two people injured and at least 1,000 homes damaged in Oaxaca. It was also reported that 14 people were killed and 15 others injured after a helicopter crashed during rescue operations.										

			Time			Dep	Magnitude			
Year	Day	Mon	UTC	Lat	Lon	km	ML	Mb	Mw	Location
2018	17	FEB	14:31	51.77N	3.83W	7	4.6			CWMLLYNFELL, NP TALBOT
Felt over much of Wales and SW Britain (5 EMS).										
2018	17	FEB	14:35	51.76N	3.82W	7	1.8			CWMLLYNFELL, NP TALBOT
2018	17	FEB	16:27	51.77N	3.83W	7	1.5			CWMLLYNFELL, NP TALBOT
2018	17	FEB	23:17	51.76N	3.82W	7	2.2			CWMLLYNFELL, NP TALBOT
2018	18	FEB	11:00	51.76N	3.83W	7	1.6			CWMLLYNFELL, NP TALBOT
2018	25	FEB	17:44	6.07S	142.75E	25			7.5	PAPUA NEW GUINEA
Over 125 people killed, 500 others injured and over 17,000 were displaced as many homes were either destroyed or heavily damaged in Hela, Southern Highlands and Western Provinces. Several landslides, sinkholes and power outages also occurred in the region.										
2018	28	FEB	07:33	54.61N	3.36W	5	3.4			COCKERMOUTH, CUMBRIA
Felt throughout the epicentral region especially in the towns of Whitehaven and Workington (3 EMS).										
2018	04	MAR	19:56	6.33S	142.60E	10			6.0	PAPUA NEW GUINEA
At least 11 people killed as a result of a landslide in the Southern Highlands region.										
2018	06	MAR	04:51	54.51N	3.02W	6	1.3			GRASMERE, CUMBRIA
Felt Great Langdale (2 EMS).										
2018	06	MAR	14:13	6.30S	142.61E	20			6.7	PAPUA NEW GUINEA
At least 18 people killed in the Hela region.										
2018	08	MAR	17:39	4.38S	153.20E	22			6.8	PAPUA NEW GUINEA
2018	09	MAR	08:14	52.76N	3.60W	12	2.7			LLANYMAWDDWY, GWYNEDD
Felt Llanymawddwy, Dinas Mawddwy, Corris, Llanellfyd, Abercywarch, Minllyn, Trawsfyndd, Bryn Golau, Machynlleth, Aberangell, Ganllwyd, Dogellau, Llanelltyd, Ganllwyd, Brithdir, Rhydymain, Llanderfel and Tregarth, Gwynedd and in Cwnllinau, Llangynog and Penybontfawr, Powys. (3 EMS).										
2018	11	MAR	18:26	53.58N	1.93W	7	1.6			MARSDEN, WEST YORKSHIRE
2018	17	MAR	16:37	59.74N	1.89E	20	2.8			NORTHERN NORTH SEA
2018	26	MAR	09:51	5.50S	151.40E	40			6.7	PAPUA NEW GUINEA
2018	29	MAR	21:25	5.53S	151.50E	35			6.9	PAPUA NEW GUINEA
2018	30	MAR	23:22	50.55N	1.83W	5	1.8			ENGLISH CHANNEL
2018	01	APR	11:11	51.14N	0.27W	5	2.7			NEWDIGATE, SURREY
Felt mainly in the RH5 & RH6 postcode areas, Surrey (3 EMS)										
2018	01	APR	11:14	51.14N	0.27W	5	1.8			NEWDIGATE, SURREY
2018	01	APR	12:11	51.15N	0.26W	5	1.7			NEWDIGATE, SURREY
2018	02	APR	13:40	20.66S	63.01W	559			6.8	BOLIVIA
2018	07	APR	21:54	51.60N	1.33W	13	1.7			EAST HENDRED, OXON
2018	08	APR	21:39	51.02N	0.04W	2	1.6			SCAYNES HILL, WEST SUSSEX
2018	13	APR	17:57	57.70N	5.26W	9	2.2			KINLOCHEWE, HIGHLAND
2018	14	APR	14:01	56.80N	5.58W	7	1.6			LOCH SHIEL, HIGHLAND
2018	20	APR	14:59	51.91N	2.94W	20	2.1			PANDY, MONMOUTHSHIRE
2018	20	APR	18:14	57.04N	1.91E	10	2.6			CENTRAL NORTH SEA
2018	23	APR	00:39	54.22N	1.58W	3	2.0			MASHAM, NORTH YORKSHIRE
2018	27	APR	16:30	52.09N	3.38W	6	1.7			BUILTH WELLS, POWYS
2018	28	APR	20:38	51.14N	0.24W	5	1.5			NEWDIGATE, SURREY
2018	29	APR	18:19	55.89N	5.58W	8	2.6			ORMSAY, ARGYLL & BUTE
Felt Tarbert, Achahoish, Ardrishaig, Minard, Clachan, Tayvallich, Srondoire, Lochgilphead, Inverneil and Portavadie.										

Forthcoming Events

2019 Conference

9-10 September 2019 in Greenwich, London – Chair: Prof. Tiziana Rossetto

Overview

The SECED 2019 Conference will be a 2-day conference on Earthquake and Civil Engineering Dynamics taking place on 9–10 September 2019 in Greenwich, London. This is the first major conference to be held in the UK on this topic since the SECED 2015 Conference (http://www.seced.org.uk/index.php/resources/seced-2015-proceedings).

The conference will bring together experts from a broad range of disciplines, including structural engineering, nuclear engineering, seismology, geology, geotechnical engineering, urban development, social sciences, business and insurance; all focused on risk, mitigation and recovery.

The conference will take place in the modern facilities of the Greenwich University Architecture Building, with the conference dinner held in the Painted Hall of the Old Royal Naval College.

Further announcements will be made through the SECED membership mailing list, the SECED website (www.seced.org.uk) and Newsletter.

Greenwich University

Conference themes

Current conference themes include:

- Geotechnical earthquake engineering
- Seismic design for nuclear facilities
- Seismic hazard and engineering seismology
- Risk and catastrophe modelling
- Vibrations, blast and civil engineering dynamics
- Seismic assessment and retrofit of engineered and non-engineered structures
- Innovations in seismic engineering design
- Earthquake reconnaissance
- Social impacts and community recovery

Keynote speakers

SECED is delighted to announce the attendance of the following keynote speakers:

- Prof. Ioannis Anastasopoulos, ETH Zurich, Switzerland
- Prof. Jack Baker, Stanford University, USA
- Prof. Dina D'Ayala, University College London, UK
- Prof. Ahmed Elghazouli, Imperial College London, UK
- Zygmunt Lubkowski, Arup, UK
- Mark Lunn, Horizon Nuclear Power, UK

Key dates

- Call for abstracts: September 2018
- Abstract submission: November 2018
- Paper submission: April 2019

More details will be announced soon.

Sponsorship

Sponsorship and exhibition packages are available. Please contact the conference Chair, Tiziana Rossetto (t.rossetto@ucl.ac.uk), for further information.

Old Royal Naval College

The Painted Hall

17th Mallet–Milne Lecture

Performance-based Earthquake Engineering – from the Cradle to Adulthood and Beyond

Prof. Andrew Whittaker, 29 May 2019 at the Institution of Civil Engineers, London

Introduction

SECED are pleased to announce that the 17th Mallet–Milne Lecture entitled 'Performance-based earthquake engineering – from the cradle to adulthood and beyond' will take place on Wednesday 29 May 2019 at the Institution of Civil Engineers. Following a long line of distinguished lecturers, 2019's Mallet–Milne Lecture will be given by Prof. Andrew Whittaker from University at Buffalo. Andrew was chosen by the SECED Committee due to his pre-eminence in structural engineering aspects of earthquake design. He is well known for the work he has put into development of various American Society of Civil Engineers (ASCE) design standards, many of which are used in the UK for the design of nuclear facilities.

Bio sketch for Andrew Whittaker

Andrew Whittaker is a State University of New York (SUNY) Distinguished Professor in the Department of Civil, Structural and Environmental Engineering at the University at Buffalo. Andrew serves as the Director of the Multidisciplinary Center for Earthquake Engineering Research (MCEER), the Institute of Bridge Engineering, and the Structural Engineering and Earthquake Simulation Laboratory at the University. He is a registered civil and structural engineer in the State of California. Andrew served as the Vice-President and President of the Consortium of Universities for Research in Earthquake Engineering (www.curee.org) from 2003 to 2011, on the Board of Directors of the Earthquake Engineering Research Institute (www.eeri.org) and the World Seismic Safety Initiative from 2008 to 2010, and on the Advisory Board for the Southern California Earthquake Center from 2010 to 2017. He is a member of the Board of Directors of the American Association for Structural Mechanics in Reactor Technology and the International Joint Research Laboratory of Earthquake Engineering, which is headquartered at Tongji University in Shanghai, China. Andrew made significant contributions to the first generation of tools for performance based earthquake engineering (Federal Emergency Management Agency (FEMA) 273/274, 1992–1997) and led the structural engineering team that developed the second generation of these tools (FEMA P58, 2000–2013). Andrew serves on a number of national committees including ASCE 4, ASCE 7, ASCE 43, ASCE 59, and the American Concrete Institute (ACI) 349 committee. He is Chair of the ASCE Nuclear Standards Committee. His research interests are broad and include earthquake and blast engineering of buildings, long-span bridges and nuclear structures. The US National Science Foundation (NSF), US Department of Energy, US Nuclear Regulatory Commission, US Federal Highway Administration, and the Canadian Nuclear Safety Commission fund his research. He consults to federal agencies, regulators, consultancies, contractors, and utilities in the United States, Canada, United Kingdom, Europe and Asia.

Technical presentation: Performance-based earthquake engineering – from the cradle to adulthood and beyond

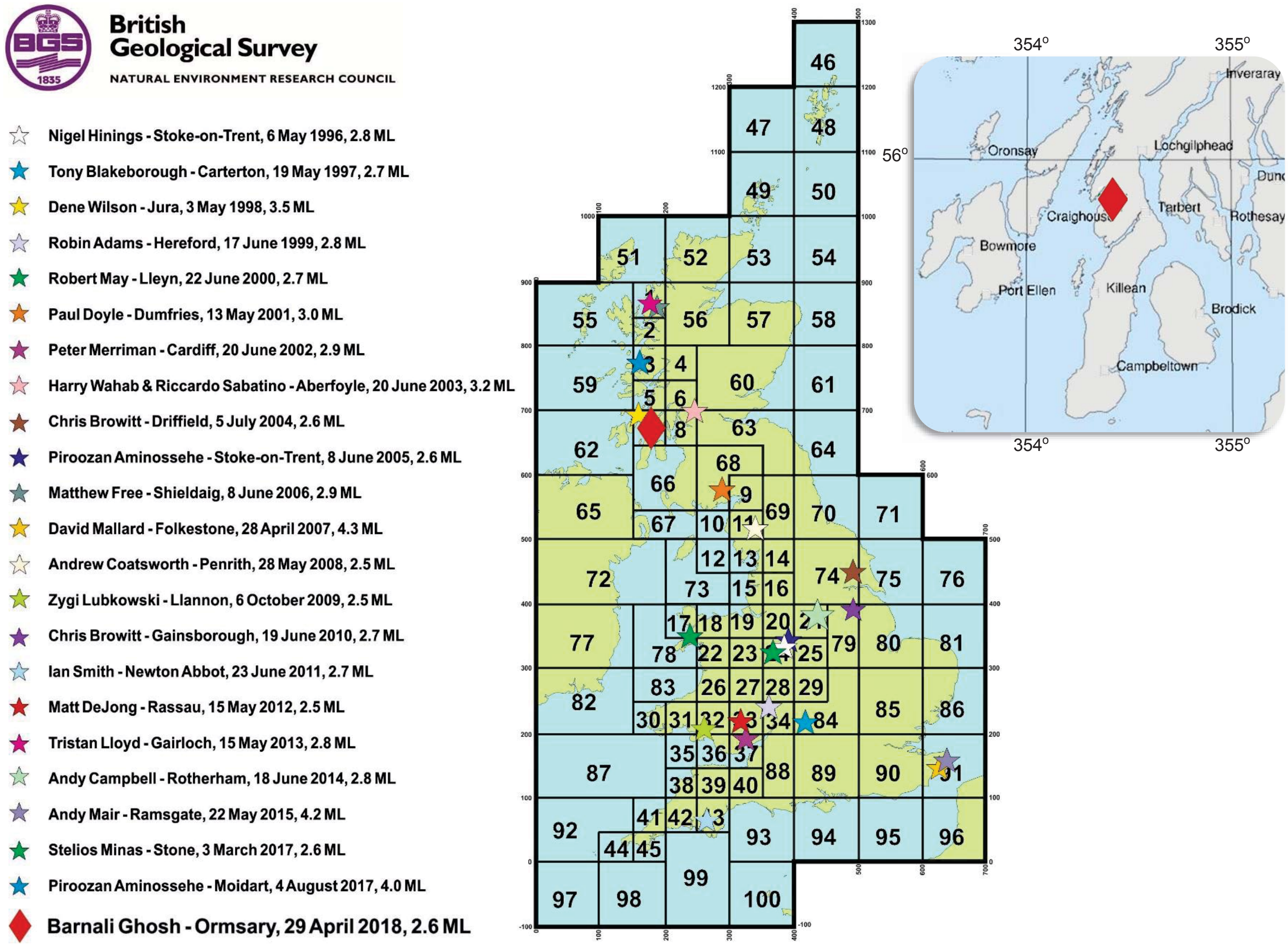
The cradle for performance-based earthquake engineering was work in the 1970s by the late Professor Sozen and his co-workers on displacement-based seismic design. Infancy followed the 1989 Loma Prieta earthquake in Northern California with applied research and development undertaken by the Applied Technology Council and funded by the Federal Emergency Management Agency (FEMA). The ATC-33 project developed technical guidelines for the seismic rehabilitation of buildings, which were published as FEMA 273/274 in 1997, the ASCE pre-standard FEMA 356 in 2000, and an ASCE Standard in 2006 (ASCE 41). These first generation tools for performance-based earthquake engineering introduced the profession to seismic performance levels, nonlinear component models, nonlinear static analysis, and deformation-based acceptance criteria at the component level. The writers of FEMA 273/274 knew of the shortcomings of these first generation tools, which included the use of discrete performance levels and defining system-level performance using component-based acceptance criteria. FEMA then funded the Applied Technology Council to develop second-generation tools for performance-based earthquake engineering (i.e., adulthood), starting in late 2000 and ending in late 2012: the ATC-58 project. These second-generation tools, which utilized seminal studies at the NSF-funded PEER Center at Berkeley, moved beyond engineering descriptions of damage to talk the language of owners, regulators and insurers, which became affectionately known as deaths, dollars and downtime. Nonlinear dynamic analysis replaced nonlinear static analysis and performance was judged at the system level. Where do we go from here? Private sector software developments, performance simulations in the cloud, and performance-based engineering for other hazards, with work on wind, fire, floods, and blast.

SECED Earthquake Competition Result 2018

This year's SECED Earthquake Competition ended four days after its onset, when an M_L 2.6 earthquake struck in Ormsary (Argyll and Bute) on 29 April 2018. Barnali Ghosh, of Matt MacDonald, became the 23rd winner of SECED's popular competition having successfully predicted that the next earthquake of M_L 2.5 or greater would occur in square #7. The usual prize of a bottle of champagne was received by Barnali's colleague, Christina Mavrommati, at SECED's May evening meeting.

Barnali kindly revealed that her strategy was 'to look at the cluster of events and gaze into the future!'. For those getting down to probabilities, the specific square has proved to be a successful choice twice so far, as Dene Wilson struck lucky by selecting it 20 years earlier in 1998's competition.

To enter 2019's competition, have a look at the figure below for previous successful predictions, select your strategy, and don't forget to inform Alice Walker, the competition organiser, about your prediction at the next AGM.



Earthquake Competition Winners, 1996–2018

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 Associated 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 please contact the SECED Secretary at the ICE at: seced@ice.org.uk.