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NEWSLETTER

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The Earth as a Musical Instrument

Frank Scherbaum's entertaining lecture summarised by **Julian Bommer**

On Wednesday 29th January an audience of 60 people, including, perhaps unusually for a Society whose meetings are generally attended by engineers and Earth scientists, about 10 musicians, assembled to hear a lecture by Professor Frank Scherbaum on "The Earth as a Musical Instrument". Frank Scherbaum is Professor of Geophysics at the University of Potsdam in Germany, well known for his papers on various seismological topics and his book on seismic signal processing *Of Poles and Zeroes*, he is also an accomplished musician (the presentation, in order to illustrate the concept of harmonics or overtones, includes a few bars from one of the most difficult guitar compositions by Brazilian composer Villa-Lobos: modestly, no mention is made of the fact in the presentation, but the piece is in fact being expertly executed by Professor Scherbaum himself).

The lecture is the result of many years work in which Frank, together with composer Wolfgang Loos, has combined his work and his hobby in a fascinating search for the geophysical songs that our planet sings. Since the project was completed a little more than a year ago, Professor Scherbaum has taken the lecture on a "tour" of Germany that would be envied by any aspiring musical group; SECED is proud to have had the privilege of hosting the first international "gig".

The starting point for the study by Professor Scherbaum and Wolfgang Loos (who first met at lectures on music theory at the University of Tübingen) was asking questions such as how does the Earth sound? Does the visual fascination of seismograms have an acoustical equivalence? Do surface waves sound differently from body waves? Do earthquakes from California sound differently from ones from China? Do micro-earthquakes signals sound differently from waves that have propagated through the inner core?

The answers to these questions are not easily obtained because seismic signals are generally in the range from mHz up to about 50 Hz, with only a small overlap with the range of human audibility (20 Hz to 20 kHz). To simply inrease the frequency of seismic waves by scaling the time scale does produce audible signals (and indeed, as Dr Chris Browitt from BGS pointed out, seismologists have often used this device to detect seismic and other

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signals visually concealed by the noise in seismograms), but they fall into the category of rather unmusical sounds that Professor Scherbaum classified as "Mickey Mouse" music, similar to the high-pitched voice of the Disney character.

Through many frustrating nights of work in a recording studio, Wolfgang and Frank eventually found a method for transposing the seismic signals into the audible range that retained their innate musicality. These transpositions have enabled them to listen to the music of earthquakes, volcanoes and whole Earth oscillations, as well as the Earth's "hum" that is thought to be due to changes in atmospheric pressure. In the lecture, Professor Scherbaum played a number of transposed seismograph signals and explained how analogies with the instruments they appear to mimic can provide insight into the mechanisms by which they are generated. Background seismicity from Bohemia, described by Professor Scherbaum as "country music", recorded by both seismographs and microphones, sounded distinctly percussive. Transposed seismograms from the Arenal volcano in Costa Rica were comparable to the sound produced by a stopped pipe, whereas recordings of rather unusual signals from Mount Merapi volcano on the island of Java produced sounds that in some cases were clearly comparable in form to those of a flute and in another case remarkably like techno dance music. On a recording from the large magnitude (M_w 8.2) earthquake that occurred at a depth of 600 km below Bolivia in June 1994, transposed by 17 octaves, the resonance of the planet created by the whole Earth oscillations was clearly audible.

In closing, Professor Scherbaum said that the Earth is making music continuously, earthquakes drumming and volcanoes imitating flutes, and even between seismic and volcanic events it continually hums. He explained that there might be considerable scope for geophysical research through the application of listening to rather than looking at seismograms, taking advantage of the fact that the human ear is far more sensitive to subtle changes than the human eye. But whilst there might be scientific potential in the technique of transposing seismic signals into the audible range, Professor Scherbaum unashamedly defended pursuing this work purely and simply for the beauty of the results. Wolfgang Loos and Frank Scherbaum, under the collective name of Kookoon, have recorded a CD of "Earth music" composed entirely from transposed seismic and volcanic signals. This "seismosonic symphony" is entitled *Inner Earth* and is published by Traumton (www.traumton.de).

After a few questions, Professor Scherbaum asked to say a few more words, having spotted SECED Honorary Life Member Dr Robin Adams in the audience. He recalled listening to Dr Adams speak at a conference in Kenya many years ago, when he urged seismologists not to be afraid of trying things that are simple. Frank thanked Robin for this sage advice that he had often recalled through his own research career. He closed by saying that after the very interesting and satisfying experience of producing the *Inner Earth* CD and delivering his lecture on "The Earth as a Musical Instrument" to audiences ranging from senior scientists to school kids, he would add his own advice in an adaptation of Dr Adams' suggestion: Don't be afraid of trying things that are crazy!

Seismic Walkdown – A Technique for Evaluating Seismic Capability

Meeting report by **John Donald.**

On Wednesday 26th February the SECED evening meeting considered the subject of Seismic Walkdown. The presentations considered the role and application of seismic walkdown methods mainly within the nuclear industry, but also considered applications to other high hazard industries.

Presentations were made by **Tim Allmark** from ABS Consulting and from **Colin Hughes** of British Energy. The meeting was chaired by **Paul Doyle** of Babtie Group.

The formal seismic walkdown approach was developed in the late 1980's and early 1990's in response to an issue raised by the US Nuclear Regulatory Commission (USNRC) A-46. This issue concerned a rise in seismic loading above the original design values at a number of US power plants and hence a potential shortfall in the seismic performance of structures, systems and components which had been qualified to the original loadings. A methodology was required to provide seismic re-evaluation for existing facilities to demonstrate their seismic adequacy against increased loadings. The US industry responded by forming a Seismic Qualification Utilities Group (SQUG) and after assessing a number of different approaches, the database approach, implemented through seismic walkdowns was adopted and subjected to USNRC scrutiny.

The formal approach adopted is termed the Generic Implementation Procedure (GIP). This contains detailed, specific requirements for a number of discrete stages to a seismic re-evaluation process.

Tim Allmark stated that the GIP approach offered a number of benefits over other methodologies which could be envisaged, these included:

- The installed items cannot be conveniently qualified through shaker table testing, finite element analysis or hand calculations.
- The GIP is considered the most economic way of providing seismic justification of key equipment items.
- The GIP is intended specifically for the seismic qualification of nuclear plant equipment where the original design has minimal or no seismic provisions.
- The GIP provides a rigorous and auditable method of assessment.
- The seismic experience database contains a wealth of information on the seismic performance of equipment exposed to real earthquakes.
- The GIP has been fully endorsed by the USNRC and is also authorised for use on US Department of Energy sites.
- A number of submissions have been presented to NII and SRD and to date no objections to underlying principles have been forthcoming.

The GIP is founded on a seismic experience database which contains information on the seismic performance of the plant and equipment within a large number of industrial facilities subjected to a range of earthquakes that have occurred in the US and other parts of the world since 1971. The ground motion estimates for the 'database' facilities ranged from 0.10g to 0.85g, with the majority lying above 0.30g and with strong motion durations in the range 5 seconds to 50 seconds. The facilities were selected on the basis that they contained substantial inventories of mechanical and electrical equipment, control systems or distribution systems.

A fundamental principle of the applicability of this database of seismic experience is that very few components within nuclear plant systems are unique to nuclear facilities, that is, much of the equipment is common to other types of industry. The range, extent and locations of the database facilities ensures that there is a wide diversity in the types of installations included within the database. Furthermore, for the equipment types considered, there is an equally diverse range of age, size, configuration, application, location within buildings, local soil conditions, and quality of construction and maintenance. Thus the failure modes apparent at conventional industrial facilities would be expected to be very similar to those which need to be resisted at nuclear facilities. An example of damage to unrestrained batteries is shown below.

Another principle in the application of the GIP is a need to ensure that the seismic motions experienced at the database facilities envelopes those predicted at the facility being re-evaluated. A generic acceleration response spectrum was developed for equipment mounted close to ground level. The facility being re-evaluated must have calculated design motions which are enveloped (or essentially enveloped) by this generic response spectrum. A procedure is also available for equipment mounted at higher levels within buildings and subjected to amplified input motions.

The ABS presentation was completed by a look at other uses of seismic walkdown techniques and at how the seismic experience database was being utilised in other engineering activities. Examples of such developments included:

- A New and Replacement Equipment (NARE) program for nuclear facilities. This program uses a procedure very similar to the SQUG GIP for the replacement of equipment at nuclear facilities which have been re-evaluated when the equipment becomes unserviceable or obsolescent.
- Pipework re-evaluation methodologies
- Cable and cable train re-evaluation methodologies
- Seismic Margin Assessments (SMA) to establish that nuclear facilities can withstand earthquakes larger than their design basis without a 'cliff edge'. These SMA assessments can use walkdowns within either a deterministic approach or in support of probabilistic safety assessments (PSA) methodologies.
- Seismic qualification of offshore oil extraction and processing platforms' Safety Essential Equipment against the demands from Strong Vibration.
- Within California a program called CalARP has utilised seismic walkdown methods to provide assurance that earthquakes would not result in releases of specified Regulated Substances such as flammable or toxic agents.

Following the presentation by ABS which provided a broad overview of the approach, its development, application and extension, Colin Hughes of British Energy then gave a presentation regarding the specific application of the SQUG developed seismic walkdown methodology at British Energy's Advanced Gas Cooled Reactor sites.

Mr Hughes presentation covered four major steps in the seismic qualification process and identified these as the following:

- Selection of seismic evaluation personnel
- Identification of safe shutdown equipment
- Screening verification and walkdown
- Outlier identification and resolution

The seismic evaluation personnel were noted to form part of a team, defined as the Seismic Review Team (SRT) using SQUG terminology. This team would include systems and plant operations engineers who could identify those equipment items required to shutdown and safety cool the reactor following a seismic event. These engineers would also be used to identify equipment including those items not required as part of the safe shutdown equipment, but which could interact with such equipment if they failed or collapsed.

The key individuals within the SRT are the Seismic Capability Engineers (SCE's), these are the engineers who actually perform the seismic walkdown using their judgement and skills. These engineers must be suitably qualified and experienced and have relevant knowledge of the type of nuclear facility under consideration and of the seismic experience database. One of the functions of the walkdown engineers is to identify when the equipment under consideration is sufficiently different from the seismic experience database to put it outside of that database and hence requiring individual evaluation. For specific evaluations, a relay engineer may also be required depending upon the specific system and its control requirements.

The identification of the safe shutdown equipment list (SSEL) is the second major step in the seismic walkdown process. Mr Hughes emphasised that not all equipment at a nuclear power plant is required to shutdown and maintain cooling of a shutdown reactor. The process identifies a success path and performs the re-evaluation for the equipment associated with that success path. In the UK, power reactors contain a number of diverse and redundant systems to perform the shutdown and cooldown processes, not all of these systems require seismic qualification.

The essential functions identified for the SSEL were:

- Protection (trip) systems
- Shutdown systems
- Post Trip Cooling, and
- Post Trip monitoring

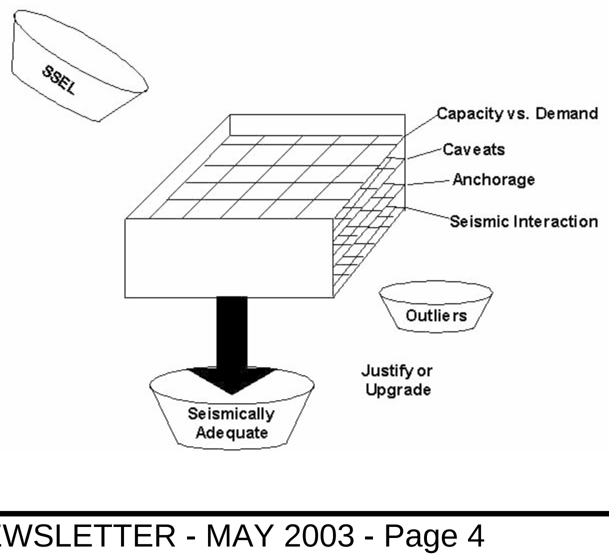
The screening verification and walkdown is the third part of the process. This is the activity most commonly known as seismic walkdown, but clearly can only be completed when the preceding activities have been performed. The walkdown is used to verify the seismic adequacy of the identified equipment or to establish the nature of any shortfall. The process requires a number of discrete activities as listed and illustrated schematically below:

1. To compare the seismic capacity with the seismic demand requires knowledge of the location and elevation of the equipment within the facility. The allowable seismic input motions which the equipment type can withstand is then compared with the seismic loadings (demand) calculated to be applicable at that location.

2. For each type or class of equipment, there is a list of caveats or rules which must be systematically checked to ensure that the equipment being re-evaluated lies within the seismic experience database of equipment which has performed adequately in previous earthquakes. This part of the process also identifies the specific type or class of equipment which defines the specific Seismic Evaluation Worksheet (SEWS) required to record the walkdown.

3. The SEWS sheet is completed to record the judgement of the Seismic Capability Engineers based on their knowledge and experience and on the system or equipment specific information. Examples of the specific information which is generally recorded includes an evaluation of the anchorage, the anchorage loadpaths, potential interactions for neighbouring equipment and structures, etc. Provided no adverse information is recorded, the equipment is essentially defined as seismically adequate at this stage.

4. Should any adverse comments or information be recorded on the SEWS sheet, then the equipment item is identified as an outlier and a follow on process is initiated to resolve the outlier status. Activities within the outlier resolution process can be as simple as arranging a follow up site inspection with suitable station personnel to permit access to a specific room or the anchorage of a specific equipment item. Items whose shortfalls cannot be rectified by further inspection or analysis may require engineering modification, upgrade, or replacement.



The talk by Mr Hughes was illuminated by a number of specific examples including horizontal tanks, valves and seismic interactions caused by unanchored equipment and insufficient clearances between evaluated equipment and non-evaluated equipment.

Following the detailed presentations, the question and answer session allowed the presenters to demonstrate their breadth of knowledge on the subject. Selected examples of the questions and answers are given below:

The biggest cause of problems was queried and noted to be anchorage and the ability to identify the type of anchors used and the material into which the anchor was attached.

A specific question was raised concerning whether the seismic walkdown approach qualified the equipment to function following an earthquake. The response was that the methodology and the underlying seismic experience database helped to ensure the seismic adequacy of the equipment, both passive equipment and active equipment which would need to function following an earthquake.

A further question concerned the resistance of masonry walls during seismic events and their potential to fail resulting in impacts upon re-evaluated equipment. Mr Hughes noted that the nuclear industry in the UK has sponsored specific tests to provide information on this subject. These tests had helped confirm that the Reserve Energy Method used by British Energy was appropriate and that an elastic analysis performed using BS 5628 was unduly pessimistic for defining the performance of masonry walls, particularly infill panels in a heavy reinforced concrete frame.

Dealing With Uncertainties in Earthquake Engineering

Dr Ricardo Duarte believes mishandling of uncertainties is almost gauranteed. **Brian Skipp** reports.

Dr Ricardo Duarte, Principal Research Officer of the National Institute for Civil Engineering, LNEC, Lisbon, spoke to a meeting of SECED on 27 November 2002. Dr Duarte has been an influential figure in the drawing up of the national seismic hazard maps and in defining the seismic hazard for the Second Tagus Crossing. In recent years he has been active in exploring the implications for engineers of current trends in the philosophy of science.

His lecture was divided into three parts: a general presentation of some current aspects of the philosophy of science and probabilism as affecting earthquake engineering, some examples of the analysis of the seismicity of Portugal and a consideration of the probability of failure of structures with reference to the probability distribution of the probability of failure.

He opened his lecture by noting that the consequences of mishandling uncertainties in earthquake engineering, save for low seismicity regions are either unacceptable risks or unjustified costs. Historical contingencies have led to general and uncritical acceptance of concepts in seismology and probability that almost ensure that uncertainties are mishandled.

Dr Duarte stated that the purpose of his lecture was to show how “scientifically disreputable” concepts such as *acceptable risk, earthquake intensity, hazard, damage index, model validation,* may be eliminated by drawing upon the philosophy of science exemplified by Wittgenstein, Quine and Putnam.

His basic of a principled version of earthquake engineering is to identify is to identify the minimal theory need to verify as completely as scientifically warranted, that a building is close to the optimal risk-cost trade off.

He set off by reminding us of some appropriate aphorisms:

- W.V. Quine, synthesis by H.Putnam: Data undermines theory; theories undermine the world – *The problems of science.*
- L. Wittgenstein – post Tractatus:
  - There is no private language – *Science is social enterpris*e;
  - Meaning and use – *Engineering is defined by its practice;*
  - There are no philosophical theories –*there is no basis to cognition problems;*
  - Philosophy is a battle against the bewitchment of our intelligence by means of language.
- E. Rosenbluth: We cannot escape subjectivity, let us indulge it and leave the rest to computers .

Dr Duarte went on to illustrate some aspects of probability in science, drawing upon Y.M Guttman (*The Concept of Probability in Statistical Physics*): The extension of the subjectivist framework; the reformulation of the aims of the ergodic approach; pragmatist foundations. He makes the point that to a pragmatist complex systems do not constitute a new ‘physical type’ with specific physical laws, but they may constitute a coherent object of study of a simple and useful theory.

Returning to the matter of language, or properly a metalanguage:
A set of propositions A_1, A_2, ...with a deterministic content define the language. Some propositions are more or equally uncertain than others for example:

Occurrence of an earthquake with $5.1<M<6.3$ at a distance of $32km<d<41km$ in a period of 14 years,
is less uncertain than,
Occurrence of an earthquake with $4.3<M<5.7$ at a distance of $18km<d<25km$ in a period of 6 years.

The uncertain propositions are ordered in a complete, reflexive and asymmetric way. This ordering is represented by a probability distribution: $P(A_1) <P(A_2)$, if and only if, A_1 is more uncertain than A_2.

Moving on to more familiar ground (for his audience) Dr Duarte described an analysis of the seismicity of Portugal based on density functions using 2D filter circles and random sampling, leading to rate of earthquake occurrence and earthquake magnitude expressed as the cumulative probability versus the probability of earthquake occurrence. He described a Bayesian analysis for the filter circles to yield the cumulative probability of magnitude (Gutenberg and Richter Law) versus earthquake magnitude and the probability of the difference between the empirical magnitude distribution and the “best” Guttenberg Richter Law.

Dr Duarte then considered the physics linking earthquake motion to structural response, and the engineering analysis linking time histories of earthquake motion to descriptive variables of both structural response and earthquake motion, with the vulnerability function mapping the relationship between the two. In dealing with the uncertainty about vulnerability functions he showed examples of how non-informative probability distributions, on the vulnerability functions, could lead to the probability of the probability-of-failure appearing constant over three orders of magnitude. He described however Bayesian iterations yielding cumulative probability distributions versus probability of failure collapsing on to a discrete value of probability of failure.

Dr Duarte moved on to touch upon non-linearity and noted that non linearity cannot be separated from hazard analysis, risk analysis, structural analysis and design analysis but it is too expensive to deal with uncertainty in the traditional way of large safety factors. We need a general theory. He refers to E.M Gold (1967 Information and Control, 10,447) stating that there is no systematic system finding a deterministic law from the input output behaviour of a mechanistic physical system. It is impossible to completely characterise the non linear hysteretic behaviour of structures and structural elements and it is impossible to calibrate a general design method when hysteretic behaviour of structures must be considered.

Dr Duarte turned then briefly to outline the computation of the probability of failure for a bridge 300m long, with radius of curvature of 500m and 2m diameter piers with concrete behaviour factor, q, of 1.5.

In closing his lecture Dr Duarte set out some final comments and conclusions:
1) The impossibility of "General Methods of Design" makes "Safety Checking" the only alternative for complex and expensive structures. There is no need for complex design methods.
2) In the "first world" the outstanding problem is to increase the earthquake resistance of existing structures which is not a problem of analysis but of costing and benefit integrating an estimate of the probability of failure.
3) It is impossible for the foreseeable future to have a "Theory of Earthquake Engineering " with the same social acceptability as other areas of civil engineering. Thus there is a need to consider a "political" input to basic decisions about safety levels.
4) A naïve engineering interpretation of the Gutenberg-Richter Law has proved incompatible with Portuguese seismicity data for the period 1910-1999.
5) When seismology concepts are used "inside engineering" they must be integrated in a coherent framework.
6) The failure of the naïve engineering interpretation of the Gutenberg-Richter law calls for more sophisticated approaches: either physically motivated possibly based on "self organising criticality", or a cognition motivated approach based on a more derailed structure of seismic data and modelling.

It is understood that the substance of the lecture will be contained and expanded upon in a book under preparation.

Seismic Strengthening of Masonry

At a recent evening meeting **Ramiro Sofronie** and **Emilia Juhasova** offered an interesting rationale for the strengthening of masonry with ductile polymer grids.

1. "Concretisation" of Masonry

Buildings damaged by recent earthquakes in Turkey, Greece, Taiwan, El Salvador and India or, indeed, by war in Iraq have highlighted the issue of masonry brittleness. Under dynamic lateral actions, both bearing structural members and in-fills are easily cracked or even crushed and dislocated. The brittleness of masonry is higher when cored bricks are used. We contend that these lightweight, thin-walled ceramic units are largely appreciated for their ergonomic qualities and not as is usually thought for isolation properties. Cement mortars also increase the brittleness of modern masonry. Masonry is the only construction material built up manually with the aid of gravity and which remains dependent on gravity throughout its service life. Since it does not fulfil the Principle of Saint Venant regarding the geometric continuity of strains, masonry is not a composite material but instead an association of two materials with similar proprieties: brittle ceramic bricks and brittle cement mortars. It is however an antagonistic relationship because bricks are produced by fire while mortars by water. This artificial stone with light aggregates is in fact concrete with the color of masonry. In other words with the aid of advanced technologies the masonry was definitely "concretised". This is far removed from the origins of the material.

Building model of reinforced masonry on a shaking table

2. The Sandwich Effect

History presents archeological and biblical evidence that masonry was invented in the inhabited regions of the Middle East scarce in natural stone. Bricks were made of burned clay and bonded with lime [or even bitumen] mortars (*Genesis 11.3*). For making the solid bricks porous and therefore ergonomic, straw was often used (*Exodus 5.7-9*). The plumb line was also known and devoted to control the verticality of masonry. (*Amos 7.7-8*). This explains why this original masonry is essentially different from the modern type. The two associated materials, elastic bricks and plastic mortars always have had complementary properties. This means that around structural faults, - like vertical joints between bricks - concentrations of stresses occur resulting in plastic strains in the mortar. Spontaneously and according to the Principle of minimum compulsion the stresses located around geometrical imperfections are gradually redistributed to neighbouring less heavily loaded areas. By this phenomenon of adaptation, known also as "sandwich effect", the original masonry protects itself against overload and is long lasting. In the particular case of dynamic loading there is no time for plastic strains to develop. In this case, the induced dynamic energy is to some extent stored in the elastic bricks as potential energy that later is gradually released and dissipated through mechanical work. To date, for masonry there were produced many computing methods called either linear or nonlinear but none has included the "sandwich effect". It is a global effect that combines the contribution of stresses and strains in the mechanism of adaptation and it is only energetically best controlled.

3. Code Provisions

Eurocode 8 formally supports the concretisation of masonry. Indeed, in ENV 1998-1-3, page 107, chapter 6 "Specific rules for masonry buildings" three methods of seismic protection are recommended: 1) Clause 6.5.3 confining the masonry with horizontal and vertical structural concrete tie-beams when the behaviour factor ***q*** is supposed to increase from [1.5] to [2.0]. 2) Clause 6.5.4 reinforcing the masonry with steel bars placed either horizontally in bed joints and suitable grooves or vertically in appropriate pockets, cavities and the holes of units when the behaviour factor ***q*** is supposed to increase from [1.5] to [2.5]. 3) Clause 6.5.5 systems of reinforced masonry industrially produced consisting of masonry units with pockets or grooves to accommodate reinforcement. In each of the three above-mentioned cases, the reinforcement should be embedded in pure cement mortar without any lime to avoid corrosion. If, however, the bars are not embedded but only anchored to their ends then at the two contact areas with masonry large concentrations of compression stresses are developed and all ceramic bricks, either solid or cored, could be crushed without any warning.

In fact all methods recommended by EC8 do not mean anything else but reinforcing the masonry with reinforced concrete. If the elastic modulus of RC is 21 GPa and that of masonry 1-2 GPa then Neumann's equivalence ratio (n = $E_{RC}/E_{m)}$ is between 10 and 20, which means that the cooperation between the two materials is not very close. If the masonry is directly reinforced with steel having E_{steel} = 210 GPa then the equivalence ratio assumes ten times larger values. The cored bricks are too weak to be reinforced with steel bars of high strength. On the other hand, ENV 1998-1-2, "Basic principle of conceptual design" in A3 (3) "Uniformity and symmetry" asserts: "A close relationship between the distribution of masses and the distribution of resistance and stiffness naturally eliminates large eccentricities between mass and stiffness." In reality, masonry with RC structural members is strongly non-homogeneous. The specific weights of the two materials differ by 25% leading to a non-uniform distribution of masses. RC structural members are mass concentrators that under seismic actions become concentrators of inertia forces. According to the Theory of Dislocations, these are the very forces originating failures in brittle masonry.

It is also surprising that EC8 by clause 6.2.1, principle P(1)a, allows the use in seismic areas of "perforated, hollow, cellular and horizontally perforated units" with holes up to 50% from their volumes. If the contact surfaces of those units with mortars are reducing in the same proportion of 50% then the stresses of compression on the thin walls of cored bricks are doubling. The cement mortars in bed layers additionally amplify the stress concentrations in these bricks. According to the clause 6.2.3, principle P(1), for such masonries mortars of high strengths, M5 to M20, should be used. The question is: "how can cored masonry be considered to have thermal properties if cement mortar is used as filling material for the holes?"

What neither EC6 nor EC8 mentions is that concrete and masonry have different coefficients of thermal expansion. Indeed, if currently for concrete is used $\alpha_c = 10^{-5}°C^{-1}$, for masonry it is only half, i.e. $\alpha_m = 0.5x10^{-5}\ °C^{-1}$. That means, under a thermal gradient of 20°C, a 5m long linear member of concrete expands by 1 mm, while a similar one of masonry only by 0.5 mm. If the thermal expansion is free then the two surfaces of concrete and masonry are simply detaching and further work independently. On the contrary, if the free expansion of the two surfaces is prevented by concrete penetration in masonry joints then by its different expansion, concrete induces shear stresses in the bricks with easily foreseen consequences. It is obvious that due to these physical conditions any cooperation between concrete and masonry in the so-called "mixed or composite structures" is out of question. This is why, for instance, the idea of "trussing" masonry with injected RC bars is questionable. It is interesting to note that since 1964 the architects, gathered to the International Charter of Conservation and Restoration endorsed in Venice, accepted to restrain themselves from associating masonry with reinforced concrete in the buildings of Cultural Heritage.

4. Masonry: Quo Vadis?

Since History never returns and the existing factories producing cement or ceramic bricks cannot be closed, the alternative is to restore the conceptual philosophy of the original masonry. At the existing levels of both knowledge and technology, one of the practical solutions immediately available consists in reinforcing masonry with polymer grids. Theoretically, the method is based on Prandtl's approach developed since 1923 in his Mathematical Theory of Plasticity. One assumes that under compressive and shear forces, when the ductile mortar reaches its ultimate limit state, bricks suddenly expel it. The polymer grids, with slender ribs and solid integrated joints, inserted in the bed layers are uniformly distributing the tensile stresses and by the "sandwich effect", any stress concentrations are prevented. Thus reinforced, the mortar is able to cooperate with all types of cored or solid bricks in any structural members of masonry. If further the masonry, either plain or reinforced, is wrapped with polymer grids and plastered then it becomes a composite material with higher bearing capacity and better behaviour under seismic actions. Laboratory tests and numerical analyses validated this innovative method. The results of static, pseudo-dynamic and seismic tests are now available together with two study cases recently completed in Romania. The method is easily applied and financially attractive while the existing database supports any conceptual design. The most important outcome of the idea is that masonry becomes again a challenging construction material. New directions of research by real and virtual simulations are also opening.

Prof R Sofronie, Prof E Juhasova. Edited by **Paul Greening**.

NOTABLE EARTHQUAKES DECEMBER 2002 – APRIL 2003

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	ML	MW	MB	LOCATION
2002	14	DEC	13:27	39.74N	97.44E	22			5.6	GANSU,CHINA
			Two people killed and 13,380 houses, 5 highways and 3 bridges damaged in the Yumen area.							
2002	24	DEC	17:03	34.59N	47.45E	33			5.1	WESTERN IRAN
			Fifteen people were injured.							
2003	11	JAN	17:45	29.59N	51.47E	33			5.2	SOUTHERN IRAN
			Several people were injured, about 650 houses were destroyed and at least 1,350 houses were damaged in the Kazerun-Nurabad area.							
2003	12	JAN	05:41	56.24N	3.74W	5	2.4			BLACKFORD,TAYSIDE
			Felt throughout Blackford with intensities of 3 EMS.							
2003	20	JAN	08:43	10.49N	160.77E	33			7.3	SOLOMON ISLANDS
2003	22	JAN	02:06	18.77N	104.10W	24			7.6	OFFSHORE COLIMA
			At least 29 people were killed, 300 people were injured and approximately 10,000 people were left homeless.							
2003	22	FEB	22:31	56.13N	5.25W	7	1.5			INVERARAY, S'CLYDE
			Felt throughout Furnace and Cairndow with intensities of 3 EMS.							
2003	24	FEB	02:03	39.61N	77.23E	11			6.4	SOUTHERN XINJIANG
			At least 261 people were killed and 4,000 people were injured.							
2003	25	FEB	03:52	39.48N	77.39E	10			5.3	SOUTHERN XINJIANG
			Five people were killed and additional damage occurred at Bachu County.							
2003	3	MAR	08:57	56.46N	6.13W	8	2.1			I OF MULL,S'CLYDE
			Felt throughout Isle of Mull with intensities of 3 EMS.							
2003	25	MAR	02:53	8.23S	120.80E	33			6.5	FLORES REGION
			At least four people were killed and 15 people were injured.							
2003	10	APR	00:40	38.21N	26.87E	10			5.7	COAST OF W TURKEY
			At least 90 people injured in the Izmir area and some damage to buildings and houses at Seferihisar.							

Issued by: Bennett Simpson, British Geological Survey, May 2003.
Data supplied by: The United States Geological Survey.

Bulletin of Earthquake Engineering

Papers are now called for the 2nd issue of the Bulletin of Earthquake Engineering (BEE). The contents page of the 1st issue, as well as the picture of the front cover, can be seen on the European Association for Earthquake Engineering website: www.eaee.org. The printed version of the 1st issue is expected in July 2003.

This new technical journal replaces the old journal that the EAEE use to produce. The editor is Prof.Dr.Atilla Ansal.

For more information visit www.eaee.org or e-mail: ansal@boun.edu.transal

Forthcoming Events

28 May 2003
9th Mallet-Milne Lecture: M.J.N Priestley
"*Revisiting Myths and Fallacies in Earthquake Engineering*"

24 September 2003
Structural Dynamics of Offshore Wind Turbines.
(Jointly with OES and WES).
ICE 5.30pm

30 October 2003 (To be confirmed)
Blast and Impact

26 November 2003
Tsunami

28 January 2004
Seabed Liquefaction

25 February 2004
Rail Induced Vibration

31 March 2004
Seismic Hazards

SECED Newsletter

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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).

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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.

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