Vol 35 No 2 MARCH/APRIL 2010

ACOUSTICS BULLETIN

in this issue... **Public acceptance of helicopter noise**

plus... **Hand-held concrete breakers**

Auditory localisation of reversing alarms

Lessons learned from acoustic testing in schools

Institute of **Acoustics**

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Contents

Front cover photograph: Helicopter noise is one of those topics for which a straightforward assessment of noise nuisance sometimes seems to be invalid. There are a number of possible reasons, some to do with the very individual nature of the noise heard on the ground, and others to do with less tangible psychological or emotional reactions. The cover picture shows a typical small civil helicopter on a low-flying task in the Pennines, where the sudden appearance of the aircraft over a hill could cause startle reactions.

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society.

Institute of Acoustics

The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has over 3000 members working in a diverse range of research, educational, governmental and industrial organisations. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, physical acoustics, underwater acoustics, together with a variety of environmental aspects. The Institute is a Registered Charity no. 267026.

Dear Members

As you are aware I have placed a lot of emphasis on supporting our regional branches during my presidency. Consequently, it was a great pleasure to visit our Irish Branch on the evening of 10 December 2009 for the annual Gerry McCullagh Memorial Lecture which took place in Armagh, Northern Ireland. The lecture given by Colin Nugent of the European Environment Agency (EEA) concerned 'Noise policy in Europe – Emerging issues and the role of the EEA'.

It was also a great pleasure to attend the inaugural committee meeting of our Welsh Branch which took place in Cardiff on the evening of 27 January 2010. I was very encouraged by the enthusiasm of all those who attended, which lead to a proposal for the branch to organise a one-day conference in Wales later this year. I wish Gwyn Mapp and his Welsh colleagues every success in this and future ventures.

The Welsh Branch committee meeting followed the highly successful one-day meeting on Wind turbine noise which, because of the controversial nature of this subject, generated an unusual amount of press interest with some of our members being interviewed by reporters from the BBC, the Daily Telegraph and other media. I was particularly pleased that Jane Davidson, Minister for Environment, Sustainability and Housing in the Welsh Assembly, arranged her busy schedule to enable her to make the keynote speech at this meeting. ***A report on the meeting is included in this Bulletin.***

The next major IOA conference is on the Validation of Sonar assessment tools, which is organised by our Underwater Acoustics group and will be held in Cambridge from 7 to 9 April 2010. This will be closely followed by the conference on Noise in the built environment which we are organising jointly with the Belgian Acoustical Association. This event will take place in Ghent on 29 and 30 April 2010. I hope IOA members will do their best to support both of these conferences.

The Institute continues to respond to public consultations and I thank everyone involved in the preparation of recent responses. I also thank Jo Webb for agreeing to take on the responsibility for overseeing the preparation and timely dispatch of all new IOA responses to consultations.

Our Continuous Professional Development (CPD) scheme has been the subject of renewed discussion both in the Membership committee and at Council. At the Council meeting in December it was agreed that we needed a more robust scheme linked closely to the education and training offered by the IOA and to Institute conferences and meetings. A small group of members have already started on a review of our current practice. I hope further news will be available after the Council meeting in March 2010.

Finally, I and other representatives of the IOA have recently met with representatives of Environmental Protection UK to discuss areas where it may be possible to expand co-operation and collaboration. Several areas of common interest were identified. It was also agreed that the IOA would encourage its members, particularly those working in local authorities and in education, to participate in Noise Action Week which will take place from 26 to 30 April 2010, and is co-ordinated by Environmental Protection UK. For further information visit www.noiseactionweek.org.uk.

John Hinton OBE
PRESIDENT

Meeting report: Midlands branch

Mike Swanwick.
Real-time directional noise monitoring

The Midlands branch returned to Scott Wilson's offices at Nottingham on 19 August 2009 for a presentation by Neil Gross of SoundScience Pty Ltd, Australia. The presentation described the development and capability of a directional noise monitoring system known as BarnOwl. Paul explained that in Australia, consent conditions for large industry such as mines, quarries, refineries, ports or wind farms often require some form of continuous or real-time noise monitoring to ensure limits are met. In areas where there are competing noise sources it is sometimes not possible to identify precisely the noise contribution from individual sources. Neil described the Hunter Valley in Australia which is a large mining area with a number of major operators in fairly close proximity. When investigating noise complaints, or for the purposes of certification, normal single channel instrumentation cannot accurately identify what sources are contributing to the measured level. BarnOwl utilises a system of three microphones and cross-correlates the signals in order to establish the noise contributions from different directions. Paul described the versatility of the system and some of the projects on which it had been used. The branch thanks Paul for his presentation and also, once again, Scott Wilson for providing the venue.

Meeting report: Midlands branch

Mike Swanwick.
Noise maps – Right or wrong?

The Branch's November meeting returned to the Arup Campus in Solihull where Nick Tinsdeall of Birmingham City Council presented an extended version of his Euronoise paper, describing the noise survey carried out in Birmingham to validate the computer generated noise maps. In 1999 Birmingham was the first city in Europe to produce comprehensive city-wide maps of transportation noise sources. A subsequent project, started in 2003, produced updated maps in 2007, and as part of the project a noise measurement survey was also carried out across Birmingham.

Nick began by outlining the mapping process using the Lima software, the many data sources required as input to the process, and the output in the form of both grid levels (on a 10m grid) and building façade levels. This information is now being used within the Birmingham City Council Environmental Protection team in support of, for example, Planning, Leisure Services, Education and Housing departments.

Two noise surveys were carried out: one based on free-field measurements on a grid basis and the second based on façade measurements. Grid locations were selected on a 3km grid across the city and then secure monitoring positions were identified as close to these locations as possible. This survey covered 31 positions. At each location continuous monitoring was carried out for seven days. The monitoring was then repeated at a time about six months out of phase with the first period. Noise indicators collected were LA10,1h and LAeq,1h from which other parameters were then calculated. Nick presented a number of comparisons between the monitored data and the mapped data and discussed the variability observed. Overall he concluded that generally the calculated noise levels are representative of the measured noise levels as there was no statistically significant difference between the data sets. Similarly there was no statistical difference between the data from the initial and the repeat monitoring surveys.

The façade survey was undertaken at 22 locations on major traffic routes for a period of 48 hours on normal weekdays. The findings of this survey were that there was no significant difference between daytime measured and calculated values, but at night-time the measured noise levels were lower than the calculated values. Nick then discussed a number of issues that may explain the variations observed.

He concluded his presentation by describing some ongoing work at BCC including a noise survey of quiet areas and a long-term noise survey being carried out using permanent monitoring systems at a number of sites across the city.

Thanks are due to Nick for his excellent presentation, and to Arup for hosting the meeting. The presentation was followed by the branch AGM.

Midlands branch half-day meeting

Mike Swanwick.
The Building Test Centre, British Gypsum

Some 43 people took the opportunity on 13 May 2009 to visit the Building Test Centre at the headquarters of British Gypsum plc at East Leake in Leicestershire. We were treated to an excellent tour of the comprehensive test facilities with some demonstrations of acoustical testing in progress. There were also presentations on current building acoustics issues.

The presentations began with an introduction to the history of the use of gypsum (calcium sulphate). The first reference to the use of 'plaster' dates back to 9000BCE. Plasterboard was patented in the USA in 1894 and British Gypsum came into being in the early 1900s. The British Gypsum product range was described, with the performance of some products being discussed in detail.

Paul Goring of National House Building Council (NHBC) Acoustic Services then presented the NHBC perspective on the reporting of complaints-driven sound insulation testing. Paul described a number of the most common causes of poor sound insulation in buildings covering design, workmanship and materials. He was also quite critical of the standard of some of the reports that the HSBC receives and presented a number of anonymous examples. He expressed concern that some reports were prepared by consultants working outside their area of expertise.

Finally, Nick Conlan of Scott Wilson presented a talk on *Acoustics and ventilation in schools*. Building Bulletin 93 addresses acoustic design and BB101 specifies the required ventilation rates. Nick mainly considered the requirements for the control of sound transmission between rooms and pointed out that BB93 requires sound insulation to be tested with windows open to meet the required ventilation rates. Nick showed, through case studies, how difficult it sometimes is to meet the sound insulation specification under these circumstances. He concluded that the demanding requirements for insulation and ventilation can be met but different strategies are required for different situations and room uses.

Many thanks are offered to the presenters, and to the Building Test Centre and their knowledgeable and helpful staff, for an excellent meeting.

Meeting report: Midlands branch

Mike Swanwick. Helicopter noise - an update

The Midlands Branch's ambitious 2010 season got off to a flying start on 26 January at Derby University with a presentation entitled *Helicopter noise – an update* by Paul Freeborn of Bureau Veritas. Paul's talk was an update on helicopter noise with particular reference to recent reports and conference papers. Helicopter noise is a controversial subject which can cause considerable distress although the number of complaints is relatively low.

Paul began with Leonardo Da Vinci's 1493 sketch of a 'helical airscrew', a concept that did not become reality until 1946 when Igor Sikorsky produced the first helicopter, the R4 Hoverfly. Paul then continued up to date with examples of modern aircraft ranging from tiny two-seaters to large machines carrying many people, servicing remote areas and the offshore oil industry. The UK has the fifth largest civil fleet of helicopters in the world, in excess of 1400.

Aircraft (including helicopters) are immune from nuisance action as long as they comply with air rules which include the requirement to maintain an altitude of at least 500 feet. Helicopters are subject to type certification for noise under ICAO Annex 16, Chapters 8 and 11. The '28-day rule' allows helicopters to operate up to 28 days per year from a site without planning permission. Local Authorities do have powers to remove this permission but they appear reluctant to use it. There are specified helicopter routes but twin-engine machines can, with appropriate permission, fly where they wish.

London in a spin, a report for the GLA in 2006, made a number of recommendations, two of which were that there should be an improved complaints procedure and a central collection and collation of data on helicopter movements in London. These roles are now undertaken by the CAA. It became clear that little was known about the extent of noise problems from helicopters.

Defra contracted the University of Salford to carry out some investigative work and they found that helicopters were about 15dB more annoying than fixed wing aircraft, but annoyance correlated poorly with noise level. They identified non-acoustical factors, or 'virtual noise', that affected annoyance responses such as the perceived effect on house prices, safety concerns, local soundscape, lack of control available to those annoyed, and general attitudes to the use of helicopters. Failure to act on complaints generated more complaints. One way to reduce complaints was to engage the local community through, for example, consultative committees. CIEH data shows that only 5% of complaints about transportation noise relate to helicopters, and in 2007 there were only 370 such complaints in the UK.

Paul introduced work undertaken by John Leverton that was reported at Euronoise last year. This work demonstrated that at similar noise levels, general aviation (smaller private aircraft eg business) are found to be more annoying than general air transport, and that helicopters are more annoying still than general aviation. However, in Aberdeen, helicopters evoke much less of a response than even general air transport. This would appear to be a clear indication of a 'virtual noise' effect due to the strong link between the helicopter and the region's offshore oil economy. Leverton quantified some virtual noise parameters. For example: flying too low adds 20dB, lack of response to complaints adds 20dB, fear adds 10dB, poor community involvement 10dB, and leisure flying 5dB. Other work reported at Euronoise by Tony Pike found that adverse response due to virtual noise could be 10 to 15 dB. He noted that spending large amounts of money trying to reduce helicopter source noise by a few decibels gave a small return compared with the potential effect of dealing with 'virtual noise' issues.

Finally, Paul drew the audience's attention to the range of roles undertaken by helicopters in the UK: air taxis, corporate use, infrastructure inspection (such as for electrical power lines), film making, news reporting, load lifting in inaccessible places, firefighting, police and air ambulance. On average an air ambulance takes off in the UK every ten minutes. He noted that the British Helicopter Association has a Code of Practice which includes a number of recommendations for minimising noise impact, and they also operate a free 'noise abatement training programme' for pilots that includes some guidance that is specific to helicopter type.

The branch gives many thanks to Paul for his very informative and enjoyable presentation, and to Derby University for again providing a venue.

IOA certificate pass list

Certificate Name: Certificate of competence in environmental noise assessment
Exam Date: 23 October 2009

Bel Educational Noise Courses
Holmes P
Joshi D
Robertson S W

University of Birmingham
Barrow N J
Crowther A L
Douglas D J
Evans R J
Langdell A
Rice G

University of the West of England
Birszwilks G
Cockram W B
Ellis H
Kirby M J
Neal B
Osman S
Russell L
Thomas C
Timothy H J
Waring M T
Watkins A L

Colchester Institute
Connolly L
De Gruchy F A
Dwyer J W
Houlihan S S
Jathoul D
Manderson I D
Marsters H E
Nicolaides C
Smith A

University of Derby
Goold A D
Hillier A M
Mackintosh P J
Molyneux J
Nash P M
Parkin C
Stevenson P R
Watson D J
Williams T H

EEF Sheffield
Maddison M C
Taylor I
Thompson M

Leeds Metropolitan University
Jones B
Thompson M
Wallace A
Williamson C A

Liverpool University
Barker A
Burns E L
Clayton J
Cronley M E
Ducie D B
Fitzpatrick O
Little R E
Lomax C
Maffia C J
Taun G

NESCOT
Akhtar S
Brown P J
Charles G
De Alexandris M
Fitzgerald D S
Hollins A J
Joseph B S
Kwofie H
Lilley H
Morgante R
Morris L
Quaye A B
Robbins L
Rowland G P
Scrivener R J
Walshe M A
Wood M R
Zhao L

Shorcontrol Safety Ltd
Callanan T
Corrigan C
Doheny J
Duffy L

University of Strathclyde
Milne A J

Certificate Name: Certificate of competence in workplace noise risk assessment
Exam Date: 6 November 2009

EEF East Midlands and Mid-Anglia
Brown T
Cook D
Grimsey S A
Jackson M W
Whitfield G M
Wilson J D

EEF Sheffield
Bissett R
Cotter J W
Gull A R
Maltby C
Raeburn S G
Rice G
Waldie R
Wroe D

Institute of Occupational Medicine
Avory R
Jackson-Burton G J

Shorcontrol Safety Ltd
Cox J
Fallon M
Fitzmaurice J A
Flynn C E B
Gibbons D
Hanley P E
Kelly A
Laxton K P M
O'Keeffe T J
Ryan J P
Walsh R

Meeting report: London branch

Annual dinner

After last year's success the London branch decided to hold its 2009 annual dinner on Wednesday 18 November at the Bleeding Heart, which has been described as 'arguably the finest French restaurant in the city'. The long-established and extremely popular Bleeding Heart, located near Hatton Gardens off Greville Street, offers superb food in historical surroundings. A private function room had been booked for the sole use of the IOA, where members were able to enjoy good food, good wine and good company in atmospheric surroundings.

This year Mike Bullen, the commercial manager at Cirrus Environmental, was invited to join the London branch as the guest after-dinner speaker. Before joining Cirrus Environmental Mike was a professional musician playing in a variety of settings in locations as diverse as the Kuwait Sheraton, Norway, and the Canary Islands. He entertained the audience with stories of his various experiences as a musician and how he moved into the world of acoustical instrumentation. Following 12 years of work in the specialised area of microwave circuitry Mike joined Cirrus Research plc, but after several years he made the decision to move to Pulsar Instruments. He recently return to Cirrus to run the Environmental division of the company.

The London branch would like to extend its thanks to Mike for taking the time from his busy schedule to join us for the evening.

Sound Tourism

Trevor Cox. The search for interesting-sounding places

At this time of year, many people are poring over guide books and travel articles to find a destination for their summer holiday. Open the average travel guide and you will read descriptions of beautiful vistas and iconic architecture to look at, along with accounts of amazing experiences readers could enjoy. But what about the wonderful sounds or striking acoustics you might travel to hear? The average travel guide contains precious little about places that sound interesting. They also rarely describe the soundscapes of popular destinations. Yet there are plenty of tourist sites where what you hear is essential to the experience, sometimes to the point of being more important than what you see. In an effort to redress the balance, I have established a web site, www.sonicwonders.org, which is an on-line guide to sound tourism: a 'rough guide' to sound.

The site is intended to be for the general public; it isn't just for acousticians. Don't worry, I'm not suggesting that all members of the Institute should go on a busman's holiday. Although if you're anything like me, I'm sure you regularly pick up on curious acoustical phenomena as you travel about. I remember visiting a church crypt in France last summer, and horrifying my wife by clapping my hands to test out the acoustics. I should point out that the room was empty: I'm not a complete heathen. I'm hoping that some of you are like me, and have experienced interesting-sounding places which can be included on the website. If you happen to think of somewhere, please send me the information: there is a link at the top of the website labelled 'suggest a place'. My hope is to increase gradually the number of places on the web site during the spring, before trying to interest the mainstream national travel media in the early summer.

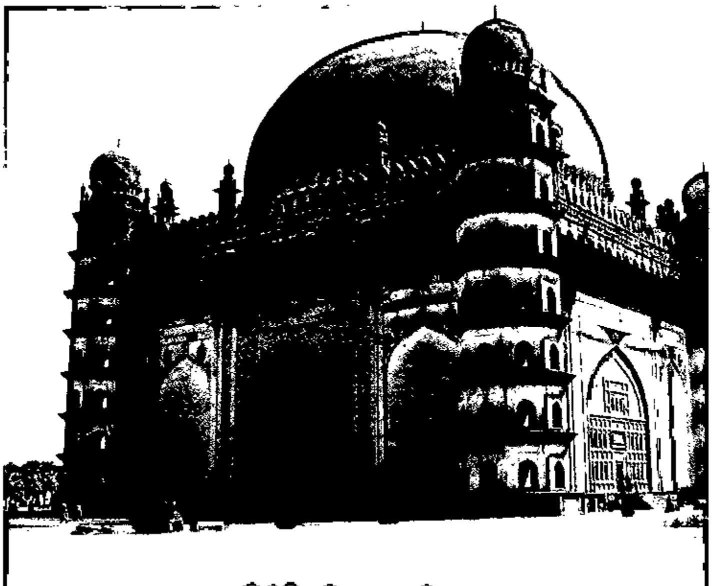
Others have assumed that the site is purely aimed at the visually-impaired, but that is not the case. I would of course be delighted if blind people found this a useful resource, and for that reason I have spent a considerable amount of time trying to make the site more friendly for people using screen readers.

The website is motivated by a couple of key issues. One of these is to provide an opportunity for a bit of lightweight science communication. The other is to make people more aware of their sound environment. In many ways we live in 'lo-fi' world where sound quality is neglected, and I would suggest that one reason is that people are not attentive to the soundscape they inhabit. We habituate to poor-sounding places, like those suffering from the constant drone of traffic noise which pollutes much of the UK, to the point that we miss out on hearing remarkable things because we are too busy shutting out the noise or listening to our iPods. I hope that the site might help make people more sonically aware.

Timeliness

There are a number of sound maps that have cropped up on the Internet in the last couple of years. By sound maps, I do not mean the noise maps being produced because of the European Noise Directive. What I am referring to is maps embedded with links to sound files, where the web site visitor can readily find sound files based on where the audio was recorded. Nowadays, the equipment to make reasonable-quality sound recordings is relatively cheap: indeed, you can use a mobile phone if you want. If recordings are geotagged, then it is relatively easy to make maps with the location of recordings marked. Displaying data geographically, often on a Google map, is a common trick on the internet.

One such map has been developed as part of the Sound Around You project (soundaroundyou.com). This asks the public to upload geotagged recordings to a web site, along with comments about the sound and a rating of soundscape quality, which gives researchers the chance to examine peoples' opinions on soundscapes. Another example comes from the BBC World Service project *Save Our Sounds* (www.bbc.co.uk/worldservice/specialreports/saveoursounds.shtml) which I worked on last year. This asked listeners to send in recordings of endangered sounds from around the world, and the audio was then loaded onto a map.



Gol Gumbaz mausoleum

With these projects, once the public have uploaded their sounds onto the map, there is not very much more for them to do. The main enjoyment seems to be in recording and archiving. If you visit these sites, a few idle moments can be spent listening to the files people have uploaded, but after that it is unclear what the causal user might do (unless you are searching the map for a specific sound you want). My new site, www.sonicwonders.org, is exploring a new use for soundmaps which I hope will attract casual users, because it is a web site about finding places to visit, rather than just being an on-line library of sounds.

One of the joys of developing the web site has been exploring the wealth of information which is now available via the internet. When you visit the site, you will see that the pages are rich in content such as sounds, photos and videos. This is now possible because sites such as Flickr, Wikipedia and YouTube contain pictures and video which are free to use for non-commercial purposes. I can even give a sense of experience people might have visiting these places based on content from travel review sites such as TripAdvisor, and this is especially useful for places I have not visited myself. Unfortunately, it is not so easy to get hold of good quality sounds. While sounds are present on many of the YouTube videos, the quality of the recordings is often terrible, with wind noise and distortion being common. Some sites such as freesound.org and soundtransit.nl are useful sources for sound files with appropriate licenses for non-commercial re-use. However, the number of non-musical sounds available on the web is surprisingly limited, and those which might be out there are often very difficult to find via search engines because they are not labelled properly.

The power of the internet goes further. SonicWonders features all the web 2.0 functionality that might be expected: user comments, rss feeds, user ratings, tag clouds, and sharing features linking to Facebook and Twitter etc. I have not had to spend months implementing all this from scratch because, as is common with many web sites nowadays, it is actually a Wordpress blog made to look like a webpage. What amazes me is how many additional features have been written for Wordpress, such as the audio player, accessible video controls and Google map plug-in I am using, which are essentially given away free.

What makes a sonic wonder?

I am still experimenting with locations to include on the site. Examining current soundmaps, it is apparent that many people get very interested in subtle soundscape features and almost-hidden sonic treasures. In the first instance, however, I think I need to concentrate on the big and brash, especially if I am to interest the mainstream travel media and the widest possible public.

Last week, I added a page on the Gol Gumbaz Mausoleum which is in India[1]. This vast 17th century mausoleum is certainly visually imposing, but the acoustics are even more impressive. Indeed, this is an example where even normal travel guides talk about the acoustic features of a place! Getting to the whispering gallery underneath the dome involves climbing a hundred or so steep, crumbling steps. If you go early enough in the day when it is not too busy, you can test the whispering gallery. Sound waves 'hug' the inside of the dome, so a whisper can be heard nearly 40m away on the other side of the gallery: it is as though the speaker was talking from just over your shoulder (you can hear the same effect in St Paul's Cathedral in London).

However, if you get to this place after the crowds have arrived then the soundscape is not so serene, as the embedded YouTube videos on www.sonicwonders.org indicate. Indeed, downstairs, it sounds more like a municipal swimming pool during a kids' float session. The subtle whispering effect is lost by the sounds of endless whooping and shouting as visitors test out the echo in the gallery. However, upstairs in the whispering gallery the dome still creates an echo. We have all heard echoes, and so this may not immediately strike you as being noteworthy, but the repeating nature of the echo in this building is very unusual, and is well worth seeking out by sound tourists. Sound keeps racing around the inside of the dome, so that three or four times a second, the sound whizzes past your ear. At quiet times, this repeating echo can be heard seven to ten times before it becomes inaudible.

However, www.sonicwonders.org does not entirely exclude more subtle sound features: 'squeaking sands' is a good example. I first experienced the phenomenon on the blindingly-white Whitehaven Beach[2] in the Whitsundays, in Australia. As you walk along the beach the sand squeaks underfoot: it is a distinctly odd acoustical effect. If you want to experience this effect closer to home, then the only beach in the UK where it happens is apparently at Porthoer in North Wales. This place is known in English as Whistling Sands, which seems a rather odd name given that the sand squeaks. The Australians are much better at being very literal in their placenames, and down under there is actually a place called Squeaky Beach.

One suggestion is that the sound is caused by friction as the grains rub against each other, but this is not proven. What is known is that the right sort of sand grains is needed: grains which are near-spherical with no sharp edges, and with the right distribution of grain sizes. This is probably why the effect is only heard on some beaches. The squeaking is most audible when the sand has been recently washed, and so it is rarely heard far from the shoreline. On the beach, the sand works most reliably when dry (although submerged and wet sand can sometimes squeak) so check the weather before travelling, especially to North Wales! If this effect is too subtle for you, then maybe consider visiting a booming sand dune instead, where sound levels can apparently reach 100dB – details on www.sonicwonders.org.

Prof Trevor Cox, President-Elect of the IOA, is with the University of Salford, t.j.cox@salford.ac.uk

Instrumentation corner

Liz Brueck. Making reliable and representative risk assessment measurements

Under the Control of Noise at Work Regulations employers have a duty to assess and control the risks to workers from noise. Risk is assessed in terms of action and limit values shown in Table 1. These are given as peak C-weighted sound pressures and daily personal noise exposure or $L_{EP,d}$ (the equivalent steady level over eight hours that corresponds to the level and duration of the noise in the working day).

	$L_{EP,d}$ dBA	peak dBC	application
Lower action value	80	135	Estimated exposure without hearing protection
Upper action value	85	137	
Limit value	87	140	Estimated exposure with any hearing protection used

Table 1

Regulation action and limit values

A risk assessment is required if a lower exposure action value is likely to be exceeded. Estimates of worker exposures should be good enough to decide whether the exposure is likely to be greater than the action values or approaching the limit values. Noise measurement is not mandatory, but in many cases it is a valuable tool. If used, measurements should be reliable and representative.

Making reliable noise measurements

The first priority for reliability is the competence of the person making the measurements. They need to know where to measure, what to measure, how long to measure for, and to understand the purpose of the measurements.

The second priority is the meter. A sound level meter or noise dosemeter that gives an LAeq reading is needed. If high-level peak sound pressures are present it is also necessary to measure the C-weighted peak value with a meter and microphone combination capable of measurements above 140dB.

For reliable measurements Health and Safety Executive (HSE) guidance requires a meter and calibrator meeting a grade and standard specification given in Table 2.

An important question arises: can you be sure your equipment actually meets its claimed specification?

The first check of performance is the before-and-after field checks with the calibrator. If the sensitivity has drifted more than expected, check for any faults with the meter or calibrator.

HSE guidance recommends the meter and associated sound calibrator are verified at least every two years, and after any repair likely to affect the performance. Table 2 lists the periodic verification test procedures to check meters against the main specifications of the standard.

The possible unreliability of the manufacturer's specification

Pattern evaluation procedures for sound level meters are defined in standards. These procedures provide confirmation that a meter model meets all the mandatory specifications of the standard. However there is no requirement in the UK for a manufacturer or supplier to take a meter model through any testing before marketing, it as meeting a National standard.

As a precaution the Health and Safety Laboratory carries out a verification test on sound level meters before the Health and Safety Executive considers them for purchase. Our experience shows that manufacturers who have successfully taken at least one model in their range through pattern evaluation generally produce meters that pass verification. When the manufacturer has never taken any sound level meter in their range through pattern evaluation, a verification test has been known to prove the manufacturer's specification to be wishful thinking. Responses can be more than 15dB outside standard tolerances even after a field calibration.

Reporting representative exposure values

Having obtained reliable measurements of the sound level you also need to consider how use them to estimate representative exposure values. Your meter may show an LEP,d value but it is usually wise to confirm this by calculation using the measured LAeq and the duration of each noisy period during the worker's working day. Remember in your calculation that 'real world' work patterns contain variability that increases the uncertainty of any calculated exposures. You may need to consider a worst-case scenario. On-line calculators for $L_{EP,d}$ can be found at www.hse.gov.uk/noise/calculator.htm.

For more information go to www.hse.gov.uk/noise, or have a look at the HSE guidance to the *Control of Noise at Work Regulations L108 Controlling Noise at Work* available as a printed copy from HSE Books or as a free download from the HSE web site.

instrument	grade of instrument	standard specification	periodic verification procedure
Integrating sound level meter	Class 1 or 2	BS EN 61672-1:2003	BS EN 61672-3:2006 with guidance from UKAS publication TPS49
Integrating sound level meter	Type 1 or 2	BS EN 60804:2001	BS 7580-1:1997 for Type 1 and Type 2, or the shorter BS 7580-2:1997 for Type 2 only
Dosemeter	Single grade only	BS EN 61252:1997	Tests based on BS EN 61252:1997 Annex B
Sound calibrator	Class 1 or 2	BS EN 60942:2003	BS EN 60942:2003 Annex B

Table 2

Performance standards for measurement instrumentation

Membership

The following members were elected, reinstated or upgraded following the Membership committee meeting on 9 September 2009.

UPGRADES

Members

Bremner, J D
Cleary, S O
Cunningham, G D
Glass, A D
Hill, S J
Hutton, D N
Livesey, H A
Lotinga, M J
McNulty, M
Stringer, D
Taylor, M O
Tee, J R
Terry, D M

Associate Members

Groborz, R V
Sibson, J E

NEW MEMBERS

Member

Abdul Majeed, B
English, E
Marshall, T M
Petillot, Y R
Wilkinson, G J

Associate Member

Bate, J
Bowden, D M
Carrol, D J
Davies, R J
Gray, D R
Green, E
Long, N C
Martin, D
Nicolaides, C
Pagett, A J
Percival, G N K
Ward, J

Affiliate

Allen, T P
Costello, K
Parker, G W
Thomas, J A
Walsh, C W

Technician

Eaton, D
Goward, N
Greenhalgh, N W

Student

Can, O
Clements, E
Kneller, F
Murray, P
Quested, C G

Sponsor

Earwood, J D
Tan, M

REINSTATEMENTS

Member

O'Sullivan, D F

Associate Member

Myles, H S
Neagle, P

The following members were elected, reinstated or upgraded following the Membership committee meeting on 5 November 2009.

Fellow

Goddard, H M
Lester, M R
Postema, M A B

Member

Albon, R M
Belton, R P
Browne, R W
Coppa, F
Filippi, F
Fish, D G
Haines, G
Hitchins, G D
Howell, J M
Jackson, S T
Kimber, R
King, E A
Kountouras, M
Liao, J
Mayor, T P
Millichope, M J
Parnell, N
Petrasso, S
Vossart, C C
Wilkinson, M J
Yates, D

Associate Member

Beer, J D
Broom, I
Clayton, D S
Clifton, M M
Conetta, R A
Elford, D
Newbery, P T
Roberts, T W
Sreetharan, D
Villoria Dohinguez, M E
Walker, H G
Wilson, M

Affiliate

Nason, J S
Protheroe, A K
Shikotra, J K
Todd, A S
Watson, N

Technician

Keogh, E
Nizamuddin, S
Soulier, D
Walsh, R

Student

Abraham, D
Bennett, R E
Childs, J A
Clark, P M
Edwards, S R
Elbourne, E
Fernandes, P
Flatt, K
Griffiths, C L
Haworth, T J
Mistry, N
Moatts, B
Moran, J
Peliza, R
Read, C
Smith, M G
Tabashiri, M
Zeman, J

Sponsor

Jacksons Fine Fencing Ltd
Instacoustic Ltd
noise.co.uk.Ltd

Meeting report

Ian Bennett. One-day meeting on wind turbine noise: Cardiff

The latest in the series of annual one-day meetings on wind turbine noise took place on Wednesday 27 January 2010 at the Millennium Copthorne Hotel, Cardiff. The meeting was also the inaugural meeting of the Welsh branch of the IOA*. A great deal of media attention was attracted to the meeting, not entirely because of the importance of the new branch, but also because the keynote speaker was Jane Davidson AM, the Minister for Environment, Sustainability and Housing in the Welsh Assembly Government. The Independent on Sunday and the Daily Telegraph have both published articles in recent months on the apparently controversial issue of wind turbine noise and whether there may be health risks associated with it.

The conference included seven technical papers besides Ms Davidson's speech, and covered a variety of current issues and areas of research including the Acoustics Bulletin Agreement (published in vol.34 no.2, March/April 2009 of *Acoustics Bulletin*), the correction of wind turbine noise assessments for wind shear, a Sonar approach to noise modulation spectral measurement, noise and noise issues from small and micro wind turbines, and statutory noise nuisance assessment on a domestic wind turbine. The elimination of wind farm noise at its roots, and a critical appraisal of 'wind turbine syndrome', were the other two topics covered.

Proceedings began promptly at 09:30 with **Andy Mackenzie** (Hayes Mackenzie Partnership) who spoke eloquently about *Wind turbine noise assessment - the IOA Acoustics Bulletin Agreement.* This Agreement among seven prominent acoustical practitioners in the field of wind farm noise was published nearly a year ago, and is finding increasing favour in Public Inquiries into wind energy developments, and in the assessment of noise from new projects in the pre-planning stage. Andy explained what the Agreement is, and why it was published in *Acoustics Bulletin*, whilst pointing out that it is not official IOA guidance and should not be regarded as such. The Agreement presents the results of discussions among an ad-hoc group, whose members had worked together many times at Public Inquiries covering vibration and low-frequency noise, noise prediction methodology, and wind shear. These topics were no longer adequately covered by the official guidance, the ETSU-R-97 report. Regarding low frequency noise and vibration, he explained the findings of the discussion group which were that there was no robust evidence that low-frequency noise (including 'infrasound') or ground-borne vibration from wind farms, generally has adverse effects on wind farm neighbours.

He then moved on to noise prediction methodology for wind turbines. The use of ISO 9613-2 was now widespread, but this raised important questions about the input data and assumptions made. The validity of the turbine sound power levels, the assumptions made about temperature and humidity, ground factor assumptions (soft or hard ground, or an intermediate condition), and the effects of barriers are all covered in the Agreement.

Possibly the most contentious issue in the Agreement was that concerned with site-specific wind shear. Andy explained wind shear and why it was important in wind farm noise assessment, and posed the question of whether a single value of site-specific wind shear could be defined before explaining how the Agreement dealt with it. This is an issue because ETSU-R-97 appears to require correlation of noise measurements with measurements of wind speed at 10m to quantify the baseline condition; IEC 61400-11 requires correlation of noise measurements with hub height wind speed 'standardised' to a 10m height to quantify turbine noise; and there is an inherent assumption in ETSU-R-97 that referencing everything to 10m height in this way provides a direct comparison between predicted turbine and background noise ... or is there? Having looked at some of the ramifications of this assumption, Andy explained the 'agreed' approach, which derives the 10m wind speeds from site-specific wind shear characteristics. This was positive for planning purposes, because it was consistent with BS.4142:1997, was a clear methodology for taking wind shear into account, and allowed meaningful evaluation of whether limits in planning conditions could be met. The negative implications were the increased degree of 'scatter'; the consequence that different noise limits would apply to different hub heights, and the economic problems for small wind energy schemes, because of the considerable costs of erecting a temporary mast 60m or 70m tall. However, Andy concluded that the Agreement's wind shear approach removes uncertainty, provides a meaningful comparison between turbine noise and existing noise under the same wind conditions, adds to the complexity of derivation of the 'prevailing' background noise level, and emphasis the question of meaningfulness of background noise measurements in rural areas.

Gavin Irvine (Ion Acoustics) followed on directly with *Alternative methods of correcting wind turbine noise assessments for wind shear.* This addressed some of the points raised by the previous speaker, by considering the ETSU-R-97 approach which may underestimate turbine noise levels if the logarithmic law wind shear assumptions (ie using a standard ground roughness length) were different from what actually occurred on the site. He reiterated the solution put forward by the Acoustics Bulletin Agreement, which was to convert each ten-minute wind speed to hub height, using data from two anemometers at different height (the higher of which should be as close to hub height as possible), using the wind shear exponent, then convert this value back to a height of 10 metres using the logarithmic law, as explained above. The problems of implementing this approach in the case of a relatively small scheme included cost (whether Lidar or a tall mast was used); the introduction of apparently spurious scatter into the data; the question of whether two weeks of data were sufficiently representative; the requirement to obtain planning permission fro a temporary tall mast; and the point that other temporary systems such as Lidar could be unreliable in low cloud conditions.

The Agreement makes provision for the use of some other method of allowing for site-specific wind shear, provided that the method is fully explained. Gavin went on to suggest one such alternative, which was to 'shift' the turbine sound power curve (sound power against wind speed) by assuming a set of different wind shear exponents. These shifted curves could then be used in noise predictions, with background noise data referenced to wind speeds measured at 10m height. This has the advantages with regard to noise limits that background noise limits can be used uncorrected, and with less scatter, and that the real effect of wind shear could be seen. The disadvantages were that the same wind shear profile was assumed for all wind speeds; that 10 metre wind speed measurements could not be used for forest or woodland sites; and that an overly conservative estimate of wind shear could lead to exceedances of the noise limits. Nevertheless, the question arose as to which value should be used for the wind shear exponent.

In order to estimate wind shear, perhaps the NOABL database could be used. This gives the average wind speed at 10m at heights of 10m, 25m and 45m based on 1km OS grid squares. Perhaps WASP could be used: the inputs needed are a terrain model, the 10m wind speeds, and estimates of ground roughness. The wind speeds at other heights could then be calculated, and used to estimate wind shear. However, the model only considers terrain effects in a neutral atmosphere.

Perhaps measured data could be used? The diurnal variation in wind shear is different from one site to another, with relatively little during the day, and considerably more at night.

Gavin concluded that shifted sound power curves could be used to evaluate the effect of wind shear; in hilly terrain, values of wind shear

Gwyn Mapp and Geoff Leventhall

Gavin Irvine

a welcome coffee to begin

a packed and attentive audience for the technical presentations

exponent greater than 0.25 were unusual, but for sites with flat terrain, practitioners should beware. When a site has planning permission, a mast would normally be installed and a detailed evaluation of wind shear over several months could be made in parallel with due diligence or certification work.

Following a coffee break, Dave McLaughlin was to present his paper, but the timings were affected by the availability and tight scheduling of the keynote speaker. In the event, a short discussion session was held before the Welsh Assembly government minister took the podium.

Jane Davidson AM is Minister for Environment, Sustainability and Housing in the Welsh Assembly Government. Although something of a political speech in the Welsh context, she was obviously very much aware of the issues of wind farm noise especially in Wales: in view of the commitment to renewable energy, onshore wind turbines had to be placed somewhere: the objective was to produce more renewable energy in Wales than is consumed, and the policy whereby this was to be achieved was shortly to be published. Marine renewables and offshore wind energy also had a part to play, but this did not remove the need for well-designed and sensitively-placed onshore wind farms.

Ms Davidson welcomed the establishment of the new Welsh branch of the IOA (the inaugural committee meeting of which was to follow the day's proceedings) and looked forward to a good relationship between her department, the Welsh Assembly and the new branch.

She followed her formal speech by taking a few questions from the floor, one of which was to so with the alleged adverse health effects of wind turbines (with a glance, no doubt, towards a paper to be presented later the same day). She responded unequivocally that there was no evidence of adverse effects on the health of wind farm neighbours, and this remained her position and that of the Welsh Assembly Government.

After these edifying remarks, **Dave McLaughlin** (Sgurr Energy) presented *Noise modulation spectrum measurement - a sonar approach*. This was an alternative way of looking into the modulation of broadband aerodynamic noise which is the main characteristic of noise emissions from wind turbines. The modulation occurs at blade passing frequency, usually somewhere between 1Hz and 2Hz, and is predominantly near-field: amplitude modulated signals from turbines do not normally propagate very far. There is a great deal of anecdotal evidence about its occurrence, but there have been few attempts to quantify it.

Dave described active and passive sonars, and the important differences between them, before asking the question we all had somewhere in the back of our mind: what did this have to do with wind turbines? The answers were remarkably simple: ships' propellers can cavitate, and even when they do not, broadband noise is produced. That noise is modulated at blade passing frequency - was this just like wind turbine noise? The sonar approach was usually to detect modulation, and classify it by frequency, but not to measure amplitude. This was achieved using a mathematical approach which yields a relationship between the modulation amplitude and the varying sound pressure signal over time. He went on to look at a spectrum of a synthesised 3dB modulation, and going through the various processes in sonar detection, showed how these might be adapted to wind turbine noise. Looking at the processes in turn, Dave produced some sample octave modulation spectra and set out some of the advantages of the technique, which included the number of variable parameters available for research purposes: noise frequency, bandwidth, and filter parameters; modulation frequency, bandwidth, and window; frequency resolution (the reciprocal of the measurement period); the ability to fix parameters for standardised measurements; its robustness against fluctuating background levels; and the capability of real-time operation.

The way ahead may be to seek consensus on the criteria for acceptable AM for wind turbines, in terms of level and sound quality (timbre); explore the causes of far-field AM, such as wind shear

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One-day meeting ... Cardiff - *continued from page 15*

and veer, and turbulence-related sources; and the effects of propagation and convergence as modified by wind shear and temperature profile.

The final presentation in the re-jigged order before lunch was the eagerly-awaited *Eliminating wind farm noise at its roots* by **Daryoush Allaei** of QRDC, USA. As it turned out, the presentation was felt by the great majority of those attending to be a considerable let-down which did not live up to its advance billing. Commercial confidentiality was cited as the reason why the assembled company could not be told anything about the physical principles behind the new invention (or development): we were told that a fundamental rethink was needed about the way in which energy was extracted from the wind by current equipment, but were given no hint of the direction to take. It was unclear to the author of this report, at least, as to whether Daryoush was talking about any form of wind turbine (in its widest sense), and whether the laws of thermodynamics were still applicable to the new invention (or development). Apparently they were still applicable, but no further information was forthcoming: whatever the principle, the noise problem was apparently going to vanish miraculously with the introduction of the 'Wind Energy Centralisation System' his company had developed. Speculation was rife over the lunch break as to whether we should be talking about some way of extracting energy from the wind, or something else entirely: if the latter, then why bother coming to a technical conference about wind turbine noise in the first place? The WECS may well be a vertical-axis turbine design, and that is hardly new (but we were not told). To record a purely personal view, I was left profoundly disappointed by the complete lack of information: if the new invention was so ground-breaking, surely it should be trumpeted only after the commercial property was secure, so why did the speaker bother to turn up in the first place? Although I would be delighted if future events were to prove me wrong, there was a distinct scent hovering around this presentation which was more reminiscent of snake oil than lubricating oil.

A very pleasant lunch, courtesy of the excellent Copthorne Millennium Hotel, followed, then **Prof Geoff Leventhall** presented *Wind turbine syndrome - End of the saga?* This was a well-reasoned and amusing paper, delivered in his usual relaxed and informal style by Geoff, which looked at the history of the infamous Dr Nina Pierpont and her writings about the effects of wind turbine noise on neighbours. Her self-published book is reviewed elsewhere in this issue of *Acoustics Bulletin*.

The symptoms described by Pierpont are those of general attitudes to unwanted noise, and there is nothing specific about wind farms. Research dating from the 1960s onwards shows that exactly the symptoms she describes arise in some degree of association with all sorts of different noise sources. Pierpont links these symptoms to low frequency sound, but there is no discernible low-frequency content to wind turbine noise that is any different from ambient low-frequency sound, that is, sounds that are already present in the environment. The levels of low-frequency sound she quotes are below the threshold of audibility up to frequencies of around 40 or 50 Hz. These are not infrasounds, they are simply sounds.

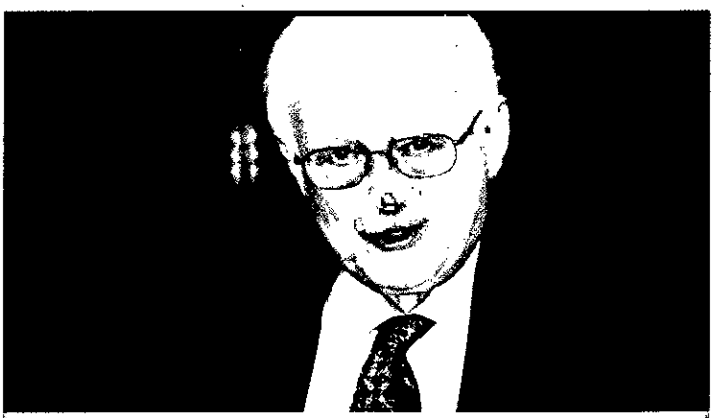
She suggests 'plausible physiological reasons' to explain the link. They may appear plausible to Pierpont, or to a lay person, but they are without foundation to a physicist, engineer or acoustician. To give one important example, she confuses the mechanism of mechanical resonances within the human body with the acoustical resonance of the body cavity. She cites the negative effects of excitation between 1 and 2 Hz from an outside source (wind turbines, by implication) and says that such frequencies disturb the vestibular system and are felt in the chest. Whether or not this is happening, there is no experimental evidence to support it. This may be because of the presence of a dominant source of energy in the frequency range 1 to 2 Hz in every human body - the heart.

Pierpont quotes 'direct experimental evidence' taken grossly out of context: her use of this information has been repudiated by the author (Dr Neil Todd), who is a neuroscientist at the University of Manchester,

Jane Davidson AM

Dave McLaughlin

Daryoush Allaei



Geoff Leventhall

as a result of his work being misquoted in the national press (the Independent on Sunday). She considered the research of Todd and his team into mechanical vibration (which included experiments on excitation of the mastoid) and related it to acoustical excitation. The mechanical resonance of a bone structure and the acoustical resonance of a cavity are entirely different, and there is no equivalence between them. It is claimed that the British team demonstrated that the inner ear was extremely sensitive to extremely low levels of low frequency noise, but this was emphatically not what was investigated, which was the mechanical excitation of the mastoid bone (the part of the skull behind the earlobe) by a direct vibration source. This is not part of the mechanism of hearing via the usual 'air conduction' route by mans of which we hear sounds (of any frequency). Pierpont deliberately inserted the work 'noise' when reporting the work on mechanical resonances on her web site between February and August 2009: the material on the web site was the basis for her self-published book on the subject of 'Wind turbine syndrome' which is only available directly from the author via that same web site.

To give another example, Dr Pierpont appears unable to understand that for a seated person, the spine has a natural frequency (at which it responds to mechanical excitation) of between 4 and 8 Hz, but the effect of a sufficiently high level of airborne sound would be to excite the resonant frequency of the chest cavity, which is typically around 50Hz in an adult, and would be higher for a child. The mechanical resonance of the spine is entirely irrelevant, but Pierpont chooses to latch onto the apparent parallel without worrying about the underlying physical principles.

Pierpont is a self-publisher who has been campaigning against wind energy for a number of years. Her qualifications are in paediatrics, and she shows no appreciation of the epidemiological techniques vital to obtain meaningful evidence in matters such as this. Her telephone surveys were of small, self-selecting populations - fewer than 40 individuals - who responded to advertisements asking about the alleged ill-effects of wind turbine noise. At no point did she pose the question as to whether the symptoms occurred before the turbines were built. This would be a fundamental control in any statistically meaningful study, but it was absent.

It is well established that noise can increase stress in people who do not want to hear it, and the effects are identical to those of the infamous 'hum' (this was a 'noise' of unexplained origin: but it could never be measured). The Pierpont 'syndrome' is nothing to do with wind turbines. Her conclusions rely on mechanisms that are at best, unproven, and at worst, ridiculous. Her case studies do not reveal any new information specific to wind turbines. The scientific merit of her findings is, at best, marginal. The result of these revelations would be, Geoff hoped, to prevent any weight being given to the allegations of adverse health effects specifically from wind turbines.

Jennifer Taylor (Nottingham University) presented *Noise issues, noise levels and noise perception from small and micro wind turbines* which had resulted from interdisciplinary cooperation between the Department of Engineering Fuel and Power Division, the Built Environment department and the School of Psychology at the University. The objective was to investigate people's perception of the noise attributed to small wind systems compared with the measured noise levels at a number of different sites. The three cooperating parties were to look at perception and annoyance related to turbine noise, the measurement of turbine noise levels, and attempt to understand the precursors for aerodynamic noise. The first was undertaken by questionnaire, and the second (and third) by direct comparative measurement.

'Small' wind turbines, in this context, are those broadly in the power output range of a few kilowatts, with rotor diameters of around 5m and hub heights between 12 and 15 metres. 'Micro' wind turbines are generally those of less than 1kW rated power, and rotor diameter no more than 1.5 to 1.7 metres on various different hub heights. Jennifer outlined the main sources of aerodynamic noise from a turbine, and explained the various installations that had been tested by her team. These were variously at a country park, and on the roofs of tower blocks for social housing. There were gaps in existing research, because work to date had been based on large or isolated turbines, noise annoyance in relation to noise sensitivity, and did not link to personality traits. The benefits of the current work, therefore, were that information could be provide to planners and policy makers for guidance on siting small wind systems, the reasons why people may experience any noise in a negative way, and how information could be better relayed to the public.

She went on to describe the initial findings of the questionnaire, which had provoked 137 responses from 12 different wind turbine installations, with a fairly normal age distribution and a 55%/45% male-female ratio. The most common words describing the perceived sounds were swoosh, hum, whistle, low-pitched or high-pitched, and buzz. Participants who could see a turbine from their dwelling had higher noise perception scores, and those with higher perception scores had higher symptom reporting scores (but the sample size was considerably lower for this aspect). Most participants reported positive attitudes to wind power, but whether or not a participant could see a turbine from their dwelling did not affect their attitude to wind turbines. Further work was postulated in which, for example, agreement could be sought between the reported sounds and the measured frequency content of turbine noise. The hypothesis could be tested that those with high frustration intolerance, a tendency to aggression, and high neuroticism could be more likely to perceive noise, and more likely to have a negative attitude to wind turbines. Jennifer went on to discuss some of the findings from direct noise measurements, pointing out that a long-term monitoring exercise such as that in the ETSU-R-97 guidance was not possible: the subject

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One-day meeting ... Cardiff - *continued from page 17*

turbines were all at very public sites. However, it was their normal practice to measure noise levels (with a B&K 2260 and suitable software) along with environmental indicators such as temperature, atmospheric pressure, wind speed and wind direction. Recordings of the sound signal were also made, and some were relayed to the audience at the conference.

The research outcomes were expected to be an identification of whether noise from small wind systems is significant; whether certain individuals are more likely to perceive wind turbine noise; how to help these individuals deal with the noise; the precursors for noise from small wind systems; and finally the establishment of a link between these four factors.

The final paper was presented by **Alick Natton**, a Senior Environmental Health Officer (Vale of White Horse District Council) wit the title *Domestic wind turbine: statutory nuisance*. He described a ticklish problem with a relatively small turbine, planning permission for which had been allowed on appeal by a Planning Inspector based on a straight application of PPS22. A condition had been applied which referred the boundary noise level to a limit 5dB above the prevailing background noise level. The Iskra AT 5-1 turbine had been installed near the edge of a village, 80m from the owner's residence, and 55m from the nearest third-party dwelling: it was this resident who complained to the Council about excessive noise, which was suggestive of tonal noise as well as the more usual swish.

It was very difficult to carry out attended measurements, for most of the usual reasons associated with wind turbine noise surveys, so an automatic monitor was installed instead. Once the Council officers were satisfied that excessive noise was occurring, an Abatement Notice was served that simply required the owner to 'abate the nuisance'. Measurements, statements from other local residents and Council officers, and sound recordings were prepared in advance of a possible hearing. The alleged perpetrator of the nuisance appealed to the Magistrates' Court, with a number of claimed legal reasons why the Abatement Notice was invalid. Rather than expose the Environmental Health Officer concerned to ad hominem attacks and questions as to competence, an independent acoustical consultant was engaged, who agreed that there was indeed a noise nuisance. This evidence, together with sound recordings, was used in Court to contest the appeal. The Magistrates' decision was that the Council's witnesses were entitled to be considered as experts, the Notice was lawful, and there was convincing evidence of the noise, which was not loud but continual, frequent and distinctive. Their Worships also held that the noise was relentless, repetitive and amounted to a nuisance, and full costs were awarded against the Appellant.

About two months after the decision, notice was received of an appeal against 'conviction and sentence'. The Crown Court office was able to clarify that this was to be a new hearing, but that the decision to allow the appeal at a 'mention and fix' hearing could be challenged as it was out of time. However, at the hearing, a different Judge decided that there were no grounds for such a challenge. Nevertheless, the appellant's solicitors eventually decided to discontinue the action.

Alick therefore posed questions about whether PPS22 really expected ETSU-R-97 methodology to apply to a small domestic wind turbine, and whether this guidance, in this context, was fit for purpose. It seemed clear that an ETSU-R-97 compliant development had been found beyond question to give rise to a noise nuisance in law, but it was a 'brave' council that had gone down this enforcement route. This had obvious implications for Permitted Development rights, currently under consultation at the IOA. The DCLG is currently saying that a noise limit of 45dB(A) at a façade is a good predictor of problems, but this was far too simplistic in the light of VRDC's experience.

Ian Bennett

*The meeting was followed by the inaugural committee meeting of the IOA Welsh branch. This will be reported in due course.

Jennifer Taylor

Alick Natton

the first committee meeting of the Welsh branch

Erratum

In Acoustics Bulletin vol.35 no.1 (January/February 2010) at page 23 the Citation for Bernard Berry was incorrectly headed. It indicated that he had been presented with an Honorary Fellowship at Euronoise 2009. This was the result of an administrative error: Bernard has been HonFIOA since 2008 and was, in fact, presented in Edinburgh with an Award for Distinguished Services to the Institute. We apologise for any embarrassment or inconvenience.

Noise emission data for hand-held concrete breakers

Jacqueline Patel. The practicalities of noise testing

Introduction

The EU Machinery Directive[1] places duties on machine manufacturers and suppliers to design and construct machinery in such a way that noise emissions are reduced to the lowest level taking account of technical progress and the availability of techniques for reducing noise, particularly at source. There is also a requirement that manufacturers and suppliers provide information on the airborne noise emissions of their products, to allow users to make informed choices regarding the safety of a potential purchase.

Standards have been developed in support of the EU Machinery Directive that define how noise emission values should be obtained for different machine types. Ideally these standard tests should provide noise emission data that is representative of the expected noise emission in normal use, allow tools of the same type to be compared, and identify low-noise tools thereby highlighting successful low-noise designs. In practice it can be difficult to design standard tests that are based on realistic operations and which give repeatable and reproducible results. It is common for standard tests to be based on artificial operations; however there is concern that the resultant standard noise emission data may not reflect the noise generated by the tool during normal use. There is a need therefore to evaluate the standard noise emission tests.

Hand-held concrete breakers are covered by both the EU Machinery Directive and the Noise Emission in the Environment by Equipment for use Outdoors Directive[2], implemented in the UK as the Noise Emission in the Environment by Equipment for use Outdoors Regulations 2001[3] (NEEEOR 2001). These regulations include the method for measuring airborne noise emissions for concrete breakers; they also require the manufacturer to declare a guaranteed sound power level that does not exceed the applicable permissible sound power level specified in the NEEEOR 2001. The guaranteed sound power level is defined as a sound power level that includes an allowance for uncertainties in the determination of sound power level due to production variation and measurement procedures.

The aims of the work reported here were:

- To assess the test method defined in the NEEEOR 2001 for usability and repeatability;
- To compare measured noise emission values with manufacturers' declared noise emission values;
- To compare the measured noise emission values with the noise generated by the same tools during simulated real-use tests; and,
- To establish whether declared noise emission data can be used as an indicator of noise hazard.

Throughout this article the guaranteed noise emission data

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Noise emission data for hand-held concrete breakers - *continued from page 19*

declared by the manufacturer and supplied with the concrete breaker is referred to as the *declared emission*. The noise emission measured by HSL in accordance with the requirements of the NEEEOR 2001 is referred to as the *measured emission.*

Tools tested

Six new breakers were obtained for testing: they are described in Table 1. All the tools were pneumatic and incorporated a silencer (muffler). All were fitted with anti-vibration handles except Tool B. The guaranteed sound power levels for the six tools tested were between 106 and 111 dB, *ie* the difference between the lowest and highest declared noise emission value was 5dB.

Standard noise emission measurements

The NEEEOR 2001 cite basic noise measurement standards and general supplements to these standards, for both measuring sound pressure levels on a measurement surface enveloping the source and for using these sound pressure measurements to calculate the sound power level produced by the source. For concrete breakers the basic noise measurement standard is BS EN ISO 3744: 1995[4].

Simultaneous sound pressure level measurements were made at six defined points positioned on a hemisphere with radius 4m according to the requirements of the NEEEOR 2001. Simultaneous measurements were made with microphones located at the six points. The output from the microphones was connected to a multi-channel real-time noise analyser. The sound pressure levels measured at each position were combined to give the A-weighted surface sound pressure level. The noise generated by the concrete breakers during the tests was steady; therefore the A-weighted surface sound pressure level was calculated from the energy average of the six measurements. The breakers were tested on a concreted area, therefore the calculations of sound power are those for a hemispherical surface of area $S = 2\pi r^2$, enveloping the source and terminating on a reflecting plane.

Figure 1 shows the test rig used for obtaining noise emission data for concrete breakers. In accordance with the requirements of the NEEEOR 2001, it consisted of a tool embedded in a 0.6m × 0.6m × 0.6m concrete block, which was placed in a concrete pit sunk into the ground. A concrete screening slab covered the block. During the emission tests, the breaker under test was coupled to the tool embedded in the concrete block. Compressed air was supplied to the breaker via an in-line regulator, which ensured the breaker was operated at the maximum working pressure specified in the instructions supplied with the tool.

To avoid parasitic noise (*ie* any noise at the measuring points generated by the breaker but not directly radiated by it), the concrete block was positioned on four anti-vibration mounts positioned in each of the four corners of the concrete pit. The cut-off frequency of the mounts complied with the requirements of the NEEEOR 2001.

The method in the NEEEOR 2001 does not specify whether the breaker shall be operated with or without an operator during emission tests. This is a significant omission. Guidance was therefore taken from the previous standard test used to measured breaker noise emission values, which is specified in the EU concrete breaker directive 84/537/EEC[5]. In this test, 'the breaker is run unattended by an operator in the manner described below:

- The breaker is operated in an upright position on the concrete block rig, which is fitted with a tool shank of the correct size for the breaker under test.
- The breaker is firmly held down by a flexible device in order to give the same stability as that existing under normal operating conditions, when the tool is embedded in the material that is to be broken up before it fractures; the flexible device may take the form of calibrated springs or pneumatic jacks, for example.'

Tool	Chuck size mm	Weight kg	Max pressure bar	Air consumption litres/min	Impact frequency Hz	Guaranteed declared sound power level dB(A)
A	32 hex × 160	27.5	7	1920	23	109
B	32 hex × 160	24.5	7	1920	23	109
C	32 hex × 160	25	6	1250	23	107
D	32 hex × 160	32	6	1560	16	106 (*a*=105; *K*=1)
E	32 hex × 160	30.5	7	1700	20	111
F	25 hex × 108	21	7	1300	22	108

Table 1

Tools obtained for testing.

Figure 1

Standard test rig used for obtaining noise emission data for concrete breakers to NEEEOR 2001 requirements

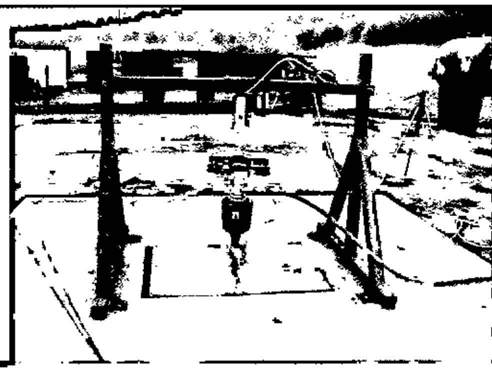

Figure 2

HSL test rig with the breaker held in place with a pneumatic jack supported by a steel crossbeam

In the HSL test rig, the breakers were held in place with a pneumatic jack supported by a steel crossbeam as shown in Figure 2.

Simulated real-use measurements

Simulated real-use tests were carried out using the six concrete breakers described in Table 1 to obtain normal-use sound power levels and sound pressure levels during realistic tasks. Three fully trained, experienced tool operators tested the breakers on concrete and tarmac surfaces. Tests were carried out using standard and vibration reduced steels; moil points were used on concrete, and tarmac cutters on tarmac.

The test area was situated roughly in the centre of an array of six microphones located at the positions defined for the standard noise emission tests. The operators were instructed to break up the

continued on page 22

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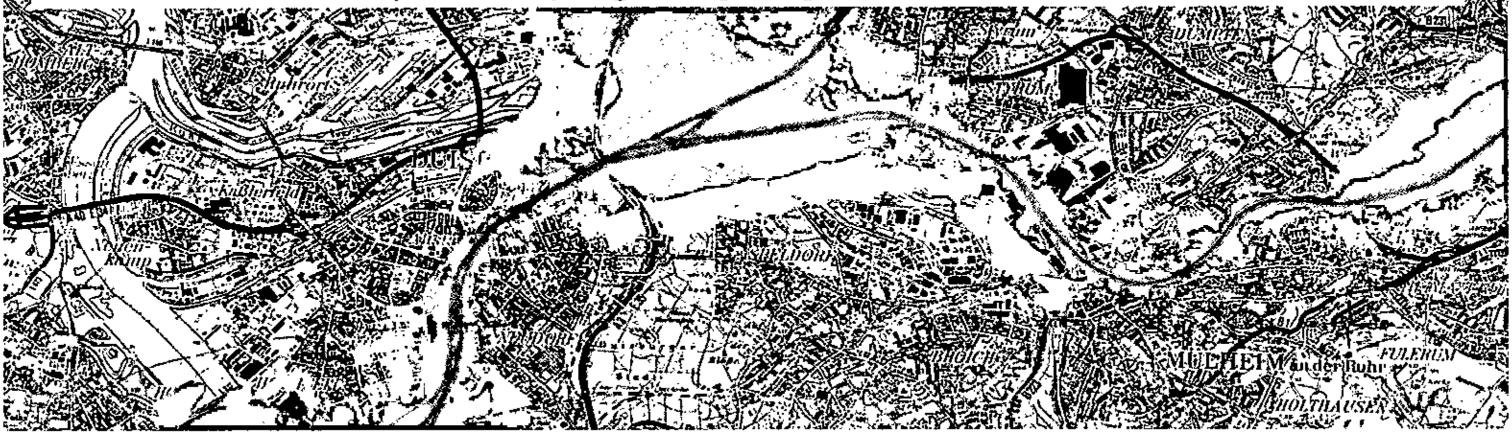

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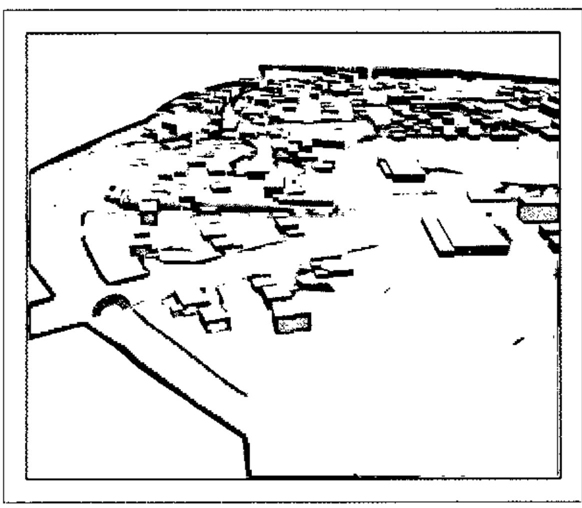
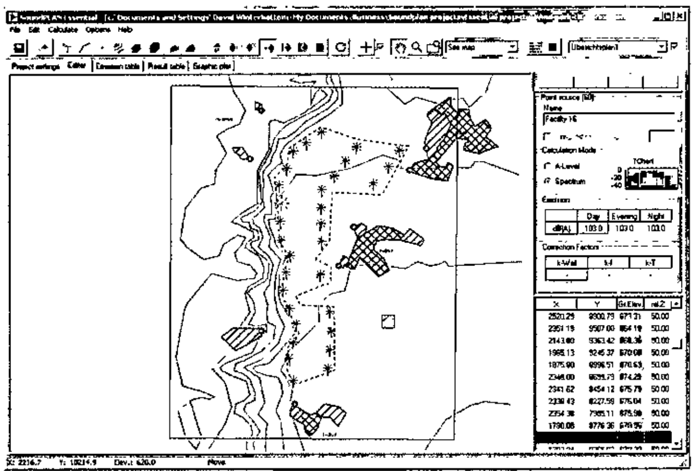


City Noise Map, Cross Section and Facade Noise Map of Road Noise with a barrier



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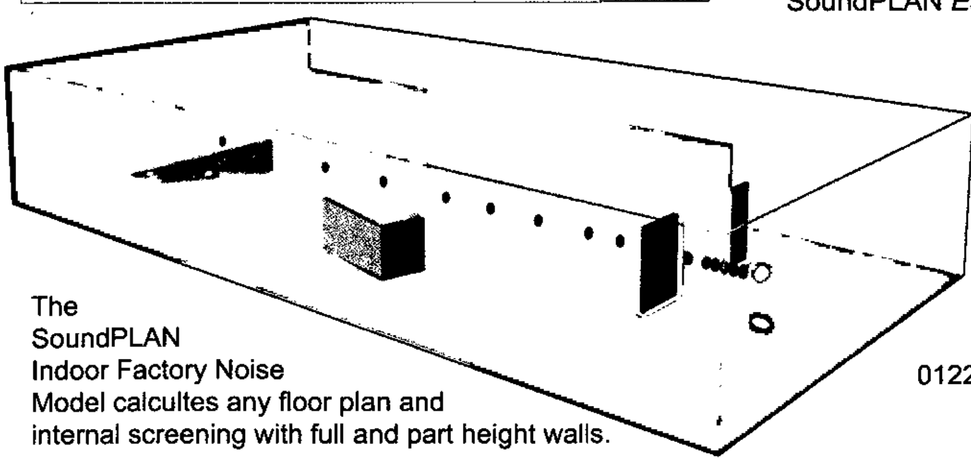

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Noise emission data for hand-held concrete breakers - *continued from page 20*

surface with the breakers as they would during normal use. Simultaneous noise measurements were made at each microphone position during these tests. This data was used to calculate the sound power level. The operator repeated the breaking task enabling noise measurements to be made close to the ear using a sound level meter, as shown in Figure 3.

Results

Table 2 contains the results of the standard noise emission tests for six concrete breakers tested using the HSL standard test rig.

Table 3 contains mean sound power levels and mean sound pressure levels measured for each of the breakers during simulated real tests. They were obtained for each breaker by combining all the data obtained for individual operators, different surfaces and different steels. These mean levels take into account all the variables that may affect the noise levels generated by a breaker, and were therefore considered a good estimate of noise levels during normal use.

Discussion

Comparison of declared and measured noise emission data

For a single tool (rather than a batch of tools), the manufacturer's declared emission is verified if the measured noise emission value, L_1 is less than or equal to the declared single-number or dual-number noise emission value[6,7].

The results in Table 2 show that HSL verified the manufacturer's declared noise emission for only two of the six breakers tested: tool B and tool C. Tool B was the only breaker tested that does not have anti-vibration handles. The largest difference between the declared and measured noise emission was for tool E. However a fault with the breaker sleeve of tool E meant it was possibly not a representative sample of this type of breaker.

Problems with the standard emission test specified in the NEEEOR 2001

Manufacturers' declared noise emissions could not be verified in the majority of cases. It was possible that this was due in part to difficulties with the standard test defined in the NEEEOR 2001. Omissions in the standard test and technical difficulties in meeting some of its requirements may result in differences between the noise emission data obtained by different test houses. The main difficulties are described briefly below:

- The NEEEOR 2001 contain no information on how the breaker should be supported during the noise emission tests, including whether or not an operator should operate the tool. Guidance was taken from Directive 84/537/EEC, however this lacks details on certain aspects of the test that may influence the measured noise levels (*eg* the vertical force applied to the breaker handles).
- Without previous experience of the test it was difficult to construct certain parts of the test rig using the information contained in the NEEEOR 2001; in particular the system of reinforcing rods within the concrete block, and the intermediate piece used to connect the breaker to the tool embedded in the concrete block.
- The NEEEOR 2001 require the concrete block to be insulated against the bottom and sides of the concrete pit with elastic blocks with a specified cut-off frequency. Although appropriate anti-vibration mounts fit into the bottom of the pit, there is insufficient space around the sides of the block to comply with this requirement.
- The test method in the NEEEOR 2001 contains several typographical errors, which hinder construction of the test rig.

Figure 3

An operator repeating the breaking task to enable noise measurements to be made close to the ear using a sound level meter

Tool	[a]Measured emission (L_1) dB(A)	[b]Declared emission (L_d) dB(A)	[c]Verified?
A	110	109	No
B	107	109	Yes
C	107	107	Yes
D	107	106	No
E	114	111	No
F	109	108	No

[a] Measured emission (sound power level) obtained using the arithmetic mean of the two highest A-weighted surface sound pressure levels;

[b] Declared single-number noise emission value $L_d = (a + K)$;

[c] Verification of the measured emission values is obtained by applying the criteria defined in BS EN ISO 4871[6] and EN 27574-2[7] ie is L_1 [illegible] L_d

Table 2

HSL measured noise emission

Tool	Sound power level dB(A)		Sound pressure level dB(A)	
	Mean	Standard deviation	Mean	Standard deviation
A	111.0	1.1	92.5	2.2
B	111.3	1.2	93.8	2.1
C	111.8	0.9	94.6	2.0
D	112.4	1.7	92.9	1.2
E	113.0	1.0	93.9	1.2
F	115.1	0.5	95.6	1.5

Table 3

Mean sound power levels and mean sound pressure levels during simulated real use.

Permissible sound power levels

One of the requirements of the NEEEOR 2001 is that the guaranteed sound power level of equipment does not exceed specified maximum permissible sound power levels. The NEEEOR 2001 were amended in 2005[8]; for concrete-breakers heavier than 15kg and lighter than 30kg the permissible sound power levels for Stage I (*ie* as from 3 January 2002) shall continue to apply for Stage II (*ie* as from 3 January 2006). This amendment in 2005 affects tools D and E. Table 4 contains the permissible sound power levels and the manufacturer's declared emission for the breakers tested at HSL.

The results in Table 4 show that both the declared and measured emission values exceed the permissible sound power level only for tool E. The consequence of this is that tool E should not be placed on the market or put into service according to the requirements of Regulation 7 in the NEEEOR 2001. However as previously discussed, it is possible that the sample of tool E tested here was not representative for this type of breaker.

Analysis of HSL measured noise emission

Before comparing the measured noise emission data obtained for the six breakers, it was necessary to establish whether the

Tool	Permissible sound power level L_w dB		Declared emission		Measured emission	
	Stage I	Stage II	L_d dB(A)	Is L_d equal to or below L_w (Stage II)	L_r dB(A)	Is L_r equal to or below L_w (Stage II)
A	110	110	109	Yes	110	Yes
B	109	109	109	Yes	107	Yes
C	109	109	107	Yes	107	Yes
D	113	111	106	Yes	107	Yes
E	112	110	111	No	114	No
F	109	109	108	Yes	109	Yes

Table 4

Permissible sound power levels.

Tool	Declared emission	Declared emission rank	Measured emission	Measured emission rank
A	109	4.5	110	5
B	109	4.5	107	2
C	107	2	107	2
D	106	1	107	2
E	111	6	114	6
F	108	3	109	4

Table 5

Ranking of breakers based on declared and measured noise emission.

measured emission values for the different tools were significantly different from each other. Statistical analysis, using one-way analysis of variance (ANOVA) and the Tukey HSD test, performed on the measured emission data showed that tools B, C and D were not significantly different at the 5% level of significance; they were therefore given the same rank.

Use of emission data to identify high-noise and low-noise breakers

Table 5 shows the results of ranking the breakers based on their emission values, where 1 indicates the quietest breaker and 6 the noisiest breaker.

The Spearman r_s correlation coefficient was calculated from the ranked data in Table 5 to investigate the relationship between the declared and measured noise emission data. At the 5% significance level, the correlation was not significant. However, when the data for tool B were excluded, the correlation between the two sets of data was significant. This shows that for breakers fitted with anti-vibration handles, the standard test produces noise emission data that are reproducible. The results for tool B suggest further work is needed to investigate the method used to obtain noise emission data for tools with fixed handles. Although the declared and measured emission values did not rank the tools in exactly the same order, they did both identify tool D as one of the quietest breakers and tool E as the noisiest breaker.

All the breakers tested were fitted with silencers which enclosed the main body of the tool. According to one tool manufacturer most silencers share the same design although there may be differences in the quality of the materials used to make the silencer. The information provided with the breakers contained no details of design features intended to reduce tool noise. The manufacturer of tool D, which was one of the quietest breakers, described using a tappet bush that has been effective at reducing noise and has a long life.

Simulated real-use noise data

The simulated real-use test on tarmac involved working an open face by cutting along the tarmac surface to break it up. This task is typical of how the breaker is used in practice. The test on concrete was less realistic; it consisted of breaking out the concrete to a depth of approximately 5cm then moving the breaker 8 - 10 cm to the side to start another break out. One operator used two of the tools to break up a concrete edge, which is a more realistic operation. The noise levels generated at the operator's ear during this more realistic task were up to 3dB higher than those generated during the simulated real use test.

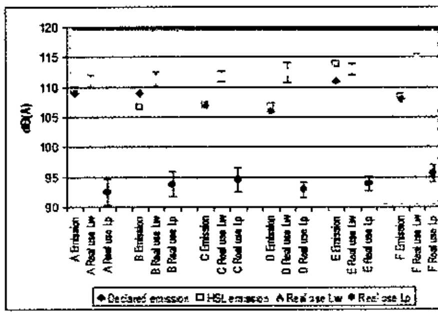

Figure 4

Emission and mean simulated real use noise levels

It is likely that the breakers will generate a range of different noise levels during normal use depending on many factors including the task, method of operation and type of surface. The purpose of the simulated real use tests reported here is to give an indication of the effect of surface type and steel type on different breakers under controlled conditions.

Effect of different surfaces

The breakers were tested on concrete and tarmac surfaces. The test results did not show a clear relationship between surface type and the noise levels generated. Statistical analysis using the related t-test suggested that choosing a heavier tool for concrete and a lighter tool for tarmac is likely to result in lower noise levels at the operator's ear.

Effect of different steels

One of the aims of the project was to investigate the methods used to reduce the noise generated by concrete breakers during normal use. The breakers were tested with standard and vibration-reduced steels. Statistical analysis using the related t-test suggested that vibration-reduced steels could make a significant difference when used with heavier tools. However there is insufficient data to explain why the vibration-reduced steels appear to reduce the sound power levels but increase the sound pressure levels, and also why they have different effects when used on different surfaces.

Ergonomic assessment of the tools

A questionnaire was administered to the operators following each breaker test to collect subjective information on productivity, comfort and ease of use[9]. The operators' comments showed that they did not like tool C; they reported that this breaker 'bounced around' on the surface and was unproductive. The operators preferred tool E because it had good handles, was the right weight and was productive. When asked to comment on whether the vibration-reduced steels affected productivity, the operators' comments were inconclusive and dependent on the surface being broken.

Comparison of emission and simulated real use data

Measured noise emission values and simulated real use sound

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Noise emission data for hand-held concrete breakers - *continued from page 23*

power levels and sound pressure levels for each breaker are shown in Figure 4. The mean simulated real use sound power levels are shown by yellow triangles, the mean simulated real use sound pressure levels by red circles; the error bars indicate the standard deviations, which were less than 2dB for all of the breakers tested. Note: In Figure 4, Lw denotes sound power level; Lp denotes sound pressure level.

The mean simulated real-use sound power levels were generally between 2 and 7 dB higher than the measured noise emission values; the mean difference was 5dB. Statistical analysis, using one-way analysis of variance (ANOVA) and the Tukey HSD test, performed on the simulated real use emission data showed that at the 5% level there was no significant difference between the sound pressure levels or the sound power levels generated by the different breakers during simulated real use.

Statistical analysis using the Pearson moment correlation coefficient r showed that there was no significant correlation between the measured noise emission values and the simulated real-use sound power levels and sound pressure levels for the breakers. The results presented here show that although the standard test produces noise emission data that are reproducible, it cannot indicate the relative noise hazard associated with different tools during normal use because the noise levels they generate are not significantly different.

One of the aims of the work reported here was to investigate whether emission data can be used to assess noise exposure of breakers during normal use. To do this, two sets of data were determined:

- The difference between the HSL measured noise emission values and the sound power levels generated during simulated real use tests (blue diamonds in Figure 5), and,
- The difference between the sound pressure levels at the operator's ear measured during standard emission tests and during simulated real use tests (pink squares in Figure 5).

In Figure 5 values less than zero indicate that the emission values underestimate the normal-use noise levels; values greater than zero indicate that the emission values overestimate the normal-use noise levels. Figure 5 shows that the measured noise emission values underestimated the sound power levels generated during simulated real use tests for tools A, B, C, D and F. It is likely that this occurred due to the additional noise generated by interaction of the steel and the surface during the breaking process. The sound pressure levels measured at the operator's position during the standard tests were either comparable with or overestimated the sound pressure levels generated during simulated real-use tests for all the breakers except tool F. The sound power level takes account of the noise radiated from the breaker in all directions. In practice the sound pressure level measured at the operator's ear will depend on many factors including the directivity of the breaker noise and the position of the operator, for example relative to the breaker exhaust.

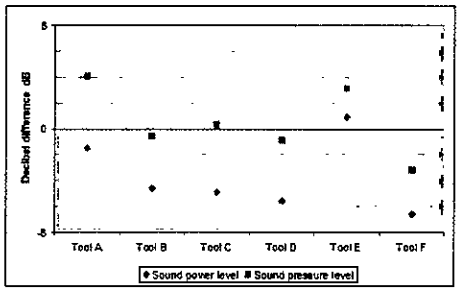

Figure 5

Difference between measured emission values and simulated real-use noise levels

Conclusions

Manufacturers' declared noise emissions could not be verified in the majority of cases. It is possible that this may in part be due to differing interpretations of the defined test method. Omissions and technical difficulties in the standard test method defined in the NEEEOR 2001 have been identified.

The noise emission data for the majority of breakers tested did not exceed the maximum permissible sound power levels specified in the NEEEOR 2001 when tested with the standard test method.

In real use the noise emission of the breakers was found to be higher, by factors between 1.5 and 5, than the noise emission obtained during standard tests. This is probably because the standard test method looks only at noise generated by the breaker itself, and not noise generated by the breaker, inserted tool, or work surface interaction. The noise emission during real use tended to exceed the maximum permissible sound power levels.

When tested using the standard test method defined in the NEEEOR 2001, there were significant differences between the measured noise emission data for some of the breakers. However the breakers generated largely similar noise levels (sound pressure levels and sound power levels) during the simulated real use tests. The measured emission values are therefore not indicative of the relative noise hazard associated with each of the individual breakers during normal use.

In general, using manufacturers' declared noise emission values as the basis of selecting or purchasing a concrete breaker will not reliably result in the selection of a machine that is low- or lower-noise in conditions of real use.

Jacqueline Patel is with the Health and Safety Laboratory, Buxton, Derbyshire. This article is closely based on the paper she presented at Euronoise 2009, Edinburgh.
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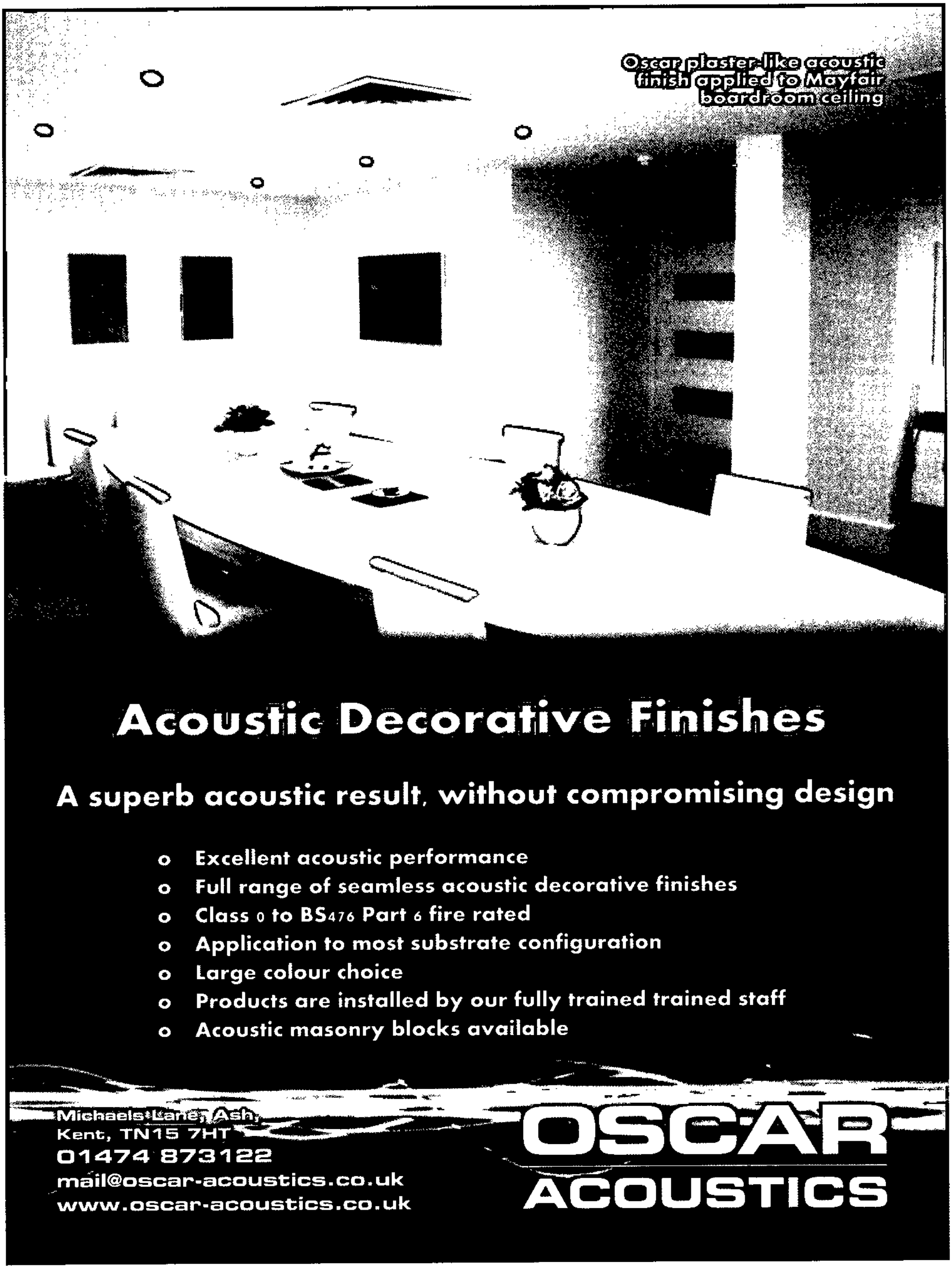
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Performance improvements, environmental benefits and build cost savings resulting from perimeter isolator technology

Roderick KT Mackenzie, Lee Nichols, R Sean Smith and Elena Prokofieva.

Introduction

In the December 2009 update of the Robust Details (RD) Handbook, Monarfloor's Bridgestop cavity wall isolation system (E-WM-19) became the first Robust Detail wall construction to achieve the full four credits available under the Code for Sustainable Homes[1]. The Code for Sustainable Homes (CSH) requires a minimum wall airborne performance of 53dB ($D_{nT,w}$ + C_{tr}) to achieve 4 Code credits for attached homes within Section 7: Health and well-being.This consistent improvement from previous RD constructions is made possible by addressing indirect flanking transmission pathways not covered in traditional designs developed to prevent direct transmission. This article outlines the background of acoustic flanking issues through cavity walls and on continuous concrete floors or rafts, the development of the Bridgestop system, and the eventual field results and build-cost savings found by developers.

Product development

The research project behind the Bridgestop system was carried out via a joint venture between Icopal Monarfloor Acoustic Solutions Ltd and the Building Performance Centre (BPC) at Edinburgh Napier University.The benefit of using flanking transmission isolators at critical T-junctions had been academically investigated over previous decades and continues today, yet there had not been a commercially viable option that was cost-effective, sufficiently robust, and could be incorporated into current cavity wall designs with minimal disruption and training for the installer. Further, the requirements of current building regulations Approved Document Part E (ADE) 2003[2] (England and Wales) or Section 5: Noise 2004 (Scotland) were met using existing RD designs, so there was no real need for enhanced acoustic performance. However, in 2006, the CSH was introduced requiring more stringent minimum airborne performances and maximum impact performances levels to achieve higher Code credits. All new social housing is currently required to achieve at least Code level three, calculated by a credit system with a maximum of four credits available for acoustics under Section 7: Health and well-being. It is desirable for housebuilders to try to attain these credits to avoid more costly alternatives stipulated within the Code. However, until Bridgestop's E-WM-19, no Robust Detail of any construction type had attained more than three CSH credits[3].

A further driver for the product development was to try to make masonry cavity wall construction on raft foundations a possibility. Historically it has not been possible to build blockwork attached dwellings on raft foundations owing to poor acoustic transmission between dwellings, due to flanking across the continual concrete raft. As was stipulated very clearly in ADE 2003 '*Do not build cavity walls off a continuous solid concrete slab floor*'. However 70% of all new builds in England and Wales are built using traditional blockwork construction, despite many new builds being built on brownfield sites which may require such raft foundations or gas barriers owing to contamination. Many housebuilders have therefore focused attention on less contaminated land to reduce costs. Alternatively, where housebuilders do want to use brownfield sites, often with central locations and higher land value returns, they are required to use 215mm dense block walls, increasing costs over lightweight aggregate (LWA) and aircrete, and limiting the attainable acoustical performance and build options.

Acoustic Issues with flanking noise

The sound insulation performance of a separating wall between two attached houses can vary from one floor level to another owing to the different structural junctions and construction materials used. Flanking sound transmission (along structures or voids which are not part of the separating partition) will influence and sometimes dominate over the *direct* separating wall's sound insulation performance. In addition to the direct pathway, a minimum of 12 acoustic flanking pathways typically exist between two horizontally-adjacent dwellings. Flanking transmission can be reduced by using twin leaf walls with a cavity and split foundations or discontinuous floor slabs. However, because of bridging across continuous raft foundations there is a significant reduction in the performance of aggregate and aircrete cavity masonry walls. Sound can transmit around a cavity separation via the concrete raft, as shown in Figure 1, from one dwelling to the next through transmission into the source room leaf, through the raft and then into the opposite leaf, with radiation into the receiving room.

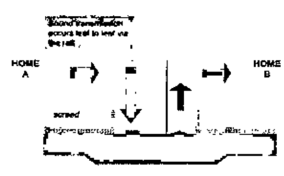

Figure 1

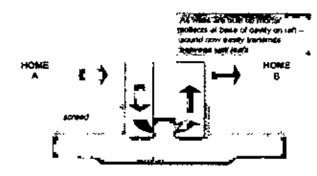

Figure 2

Figure 1: Sound transmission pathway through a continuous raft foundation, and Figure 2: through mortar collected at the base of a cavity.

Figure 3

Figure 4

Figure 3: mortar collection on cavity wall methane gas membrane barriers and Figure 4 for radon membrane barriers.

Even with close monitoring of the construction, heavy mortar collection is a possibility on ties and at the cavity base, as shown in Figure 2, providing an additional acoustic bridge for *direct* sound transmission between the two leaves, reducing the performance of a cavity wall. Field examples of this can be seen in Figures 3 and 4.

In buildings with continuous vertical cavities stretching up three or more stories, it can be observed that a noticeable drop of up to 6dB ($D_{nT,w}$ + C_{tr}) in wall performance occurs from the second to ground floor walls: this is attributable to mortar collection on wall ties (Figure 5).

The combined effect of transmission through the raft and the mortar bridging can reduce the wall's performance still further, by up to 8dB ($D_{nT,w}$ + C_{tr}), as demonstrated in the next section.

Flanking isolation solutions

With regards to acoustic flanking transmission across raft foundations, the Monarfloor® Bridgestop system was designed to reduce significantly the transmission between party wall junctions and the

continued on page 28

Performance improvements ... perimeter isolator technology - *continued from page 26*

concrete sub-floor (Figure 6). In this system, a 3mm thick combined bitumen/aluminum acoustic membrane (of varying widths) acts as an isolator at lower frequencies and as an acoustic dampener for high frequencies. It also serves to act as a protective layer, stopping radon or methane barriers beneath being damaged by mortar droppings being cleared from on top of them, or where the slab has been split, protecting the installed gas barrier. By placing the continuous isolator under each leaf (thus simplifying installation) there is a doubled isolation effect between wall leaf and support and wall leaf to wall leaf.

A secondary benefit of the system is to reduce this mortar bridging by inserting and folding over a 10mm reconstituted polyether-polyurethane quilt fixed (by acoustically resilient plastic ties with an 8mm spacing tab on the outer face as a render thickness marker) to one leaf on the cavity side, isolating the mortar build-up from connecting both leaves. If the Bridgestop system is placed across party walls at every floor level, it collects mortar spilt and swept into the cavity and reduces the amount of mortar which collects on wall ties, avoiding an acoustic bridge. Bridgestop was specifically designed to cope with loading factors present in blockwork builds by having minimal compression under load. Granular finishes on both materials ensure the material does not act as a slip plain under shear and wind loading. The Bridgestop system is beneficial to semi-detached, terraced, and townhouse dwellings and can also be applied at each floor level for apartments. For high-rise reinforced concrete frame with continuous in-situ floor slabs Bridgestop can also be applied in conjunction with perimeter isolators at the columns. The first phase of Bridgestop's entry into the robust details route has been targeted at attached houses and at present other applications would operate through the pre-completion testing route for compliance.

4. Acoustical testing

Field trials of the Bridgestop system under the candidate RD scheme were completed in late 2009, delivering a mean performance of 55dB ($D_{nT,w} + C_{tr}$). The results of this test series can be seen in Table 1. It was accredited as the first four-credit performing RD wall under the CSH, using 100mm cavities and LWA, dense block, or Besblock Star performer cellular blocks. Before this, Bridgestop was detailed as an RD Appendix A2. Between July 2007 and August 2009, the mean result over the thirty tests was 56dB ($D_{nT,w} + C_{tr}$), with the lowest result being 53dB and the highest 65dB. All these results indicate performances of four CSH credits, despite a clear variability in build quality between walls even on the same sites, meaning the system is a robust solution to tackle workmanship issues. For Aircrete walls, eight tests have to date been conducted in field trials on 100mm cavities, with a mean performance of 55dB ($D_{nT,w} + C_{tr}$).

In one example of field testing where there was a direct comparison of testing ground floors on rafts with and without Bridgestop, tests were conducted on two 100mm cavity walls of RD design E-WM-1, built on a concrete raft. Both sets of rooms tested (in a manner conforming to the requirements of ADE 2003 and ISO 717-1) were identically designed bedrooms (volume 25m^3) and partitions were the same dense blockwork construction using the same materials; however one partition had the Bridgestop system present.

It can be seen from Figure 7 that the partition tested without Bridgestop achieved an airborne level difference of 49dB ($D_{nT,w} + C_{tr}$), below the requirement of the RD mean performance, and the test partition would achieve only one CSH code credit. With Bridgestop present, however, the same construction achieved an airborne level difference of 57dB, an improvement of 8dB ($D_{nT,w} + C_{tr}$). It would appear that Bridgestop's properties have high acoustic damping to absorb more sound energy and reduce flanking through isolation, performing approximately 4 -8 dB better than solid walls (which receive no credits) and 2 - 6 dB better than standard party walls.

Environmental benefits and cost savings

In addition, results have shown that only one coat of render instead of two is required to achieve 4 CSH credit performance, as well as standard plasterboard (8kg/m^2) instead of 12.5kg/m^2 for solid Part E solution walls, saving 4.5kg/m^2 of gypsum-based board per m^2. The potential annual new build savings in building materials by using Bridgestop are approximately 4000 tonnes per annum.

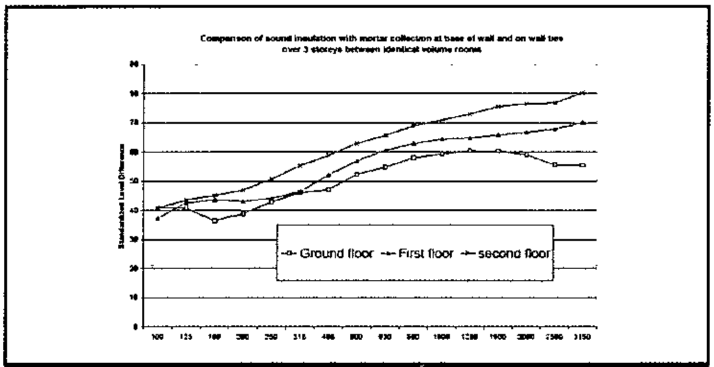

Figure 5

Reduction in standardised level difference due to mortar collection, with vertically adjacent dwellings of the same twin-leaf LWA construction with continuous cavities

It also serves to maintain the integrity of gas/radon barriers on split foundations protecting the occupant's health and safety. The isolation of the separating wall at ground floor level allows the foundation to be installed within a more shallow formation than that for a separating wall being built to the current guidelines with a 225mm cavity below ground floor. There is additional time and cost savings from the reduction in excavation and spoil. All these savings combined demonstrate a significant cost saving in time and materials and flexibility in the design and build of the development.

Conclusions

The development of two innovative perimeter isolation technologies into design specifications gives builders the opportunity to achieve the maximum of four Code credits for the first time, without changing the dimension specification. The Bridgestop system has been shown to isolate flanking transmission through cavity blockwork party walls and raft foundations by reducing flanking effects of rafts and mortar bridges, performing approximately 4 - 8 dB better than solid walls and 2 - 6 dB better than standard party walls. The Bridgestop system will significantly increase options for blockwork and the concrete industries in raft foundations on brownfield sites.

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This article is closely based on the paper presented by Rod Mackenzie at Euronoise 2009, Edinburgh.

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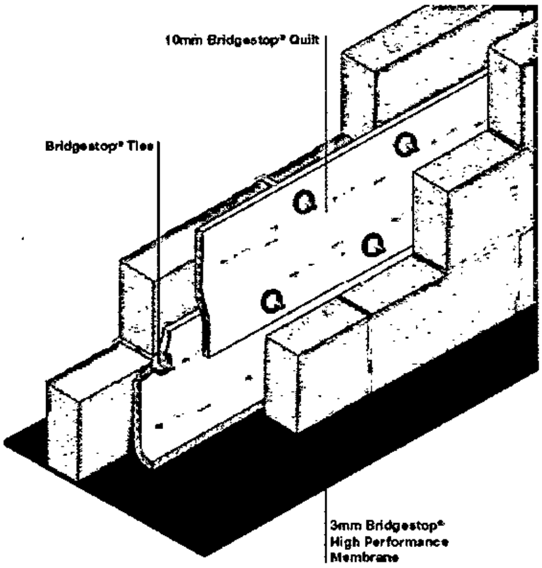

Figure 6

Bridgestop system installed in a cavity wall

RD wall type	$D_{nT,w} + C_{tr}$	CSH credits	RD wall type	$D_{nT,w} + C_{tr}$	CSH credits
E-WM-4 (100mm cavities)	54	4	E-WM-12	57	4
	55	4		58	4
	54	4	E-WM-11	57	4
E-WM-4	53	4		58	4
	57	4		54	4
	54	4		54	4
	54	4		54	4
E-WM-4	56	4		58	4
	58	4	E-WM-5	54	4
E-WM-11	60	4		55	4
	54	4		58	4
	65	4	E-WM-4	57	4
				57	4
				57	4
				54	4
				56	4
				54	4
				55	4

Table 1

Results of 30 field trials under candidate RD application

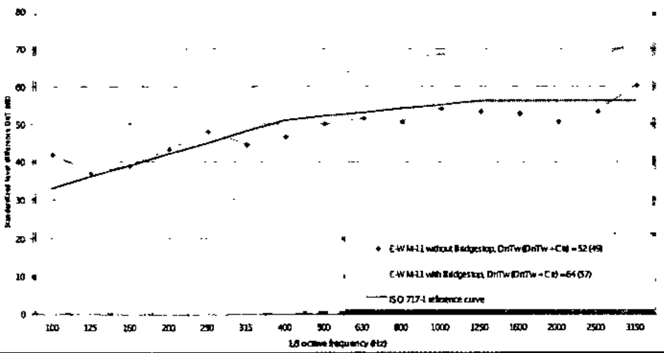

Figure 7

Comparison of two identical RD E-WM-1 walls, with and without Bridgestop system built into wall cavities

Auditory localisation of a fork-lift truck reversing alarm with hearing protectors

Pedro M Arezes and Liliana Maia.

Introduction

Noise exposure in occupational settings has been a source of several studies and research, but the phenomenon of noise also occupies some prominence in the concerns of society, since it affects a significant proportion of the population and presents a large diversity in what concerns the sources of emissions.

Auditory perception is one of the most important senses, other than vision, used to access the knowledge of space and thus is also useful to recognise the distance from the acoustical stimulus and its spatial location.

Noise exposure is not only a cause of hearing loss, but also a source of verbal communication degradation, decreasing the workplace safety and workers' performance[1]. As a consequence of this, the use of hearing protective equipment is increasing. However, the selection process for hearing protection devices (HPDs) is not always done properly. Many workers complain that the use of hearing protective equipment does not allow them to communicate, or to hear and locate important warning sounds at the workplace[2-3].

It is also agreed that, in addition to the characteristics of attenuation of hearing protection equipment, there are other important factors that may affect the individual ability to perceive auditory signals. These factors include the comfort afforded by the devices, the attention (or lack thereof) of the listener, the characteristics of the warning signals and the users' hearing loss[4].

This work aims to analyse the influence of the use of individual hearing protection in the perception of space localisation and distance identification of a backup alarm signal used in industrial fork-lift trucks for identifying the operation of the vehicle when moving in reverse.

Methodology: laboratory procedure

Considering the objectives for this study, and in accordance with the definition of a specific test laboratory procedure, a 'real' exposure environment was simulated in a laboratory setting. Twenty test subjects agreed voluntarily to collaborate in the study and were involved in the tests. To be included in the study sample, subjects had to have no experience of industrial work or HPD use, and not previously diagnosed hearing disorders.

As auditory signal source, a source commonly found in the manufacturing sector was used: the audible signal of a backup or 'imminent movement' alarm used in goods vehicles, industrial fork-lift trucks and other mobile machinery. With this objective, the audible signal was pre-recorded as a sound file (.mp3) and played at the laboratory. The characteristics of the acoustical signal and its duration were kept unchanged[5]. The tests carried out considered the analysis of users' performance for sounds located only in the horizontal plane in a reverberant environment[3], and the height of the source being 1300mm.

The physical space where the tests took place was a hard-walled and empty room, 6m wide and 8m long, and trials were first conducted with the noise source absent, in order to determine the background noise. Figure 1 shows the layout of the room, and the grid of nine acoustic stimulus source positions at 2m intervals.

Regarding the type of hearing protectors tested, because of the enormous range of protection available, it was decided to use one HPD of each type, but giving preference to the models frequently used in Portuguese industry. Three types of protection were selected: two passive devices, earplugs and earmuffs, and an active earmuff, an electronic model with level-dependent attenuation.

Passive HPDs are generally characterised by providing an attenuation that is independent of the external sound pressure level of the environment. However, according to some authors[6] it is this passive attenuation characteristic that may lead to a compromised hearing ability during quieter periods of an intermittent sound exposure.

Non-passive devices, such as the active HPDs with a level-dependent mechanism used in this study also called amplitude-sensitive sound transmission HPDs, try to address this problem by providing reduced attenuation at low sound levels, with increasing protection at high levels. They usually consist of modified convention¬al earmuffs incorporating some electronics, typically microphones and amplifiers, to transmit external sounds to earphones mounted inside the earcups. This amplification is limited to a predetermined at-ear level, which should be equal to or less than the appropriate action level. Therefore, non-passive HPDs offer a desirable approach to protection both in terms of attenuation characteristics and, hypothetically, in terms of the HPDs' ergonomics.

The adopted test procedure consisted of several stages that had to be completed by all the test subjects, which included the following steps.

(1) The subject was placed on a pre-defined position near a wall (Figure 1) and with his or her back to the source test position grid, in order to prevent the source locations being seen by the subjects.

(2) The order for the type of protection used was generated randomly.

(3) The procedure also included also a test with no hearing protection being used.

(4) For each of the tested protection conditions (including 'no protection') three out of the nine possible positions were randomly selected for placement of the sound source.

(5) Each subject was effectively required to identify each source position by direction (left, centre and right side of the subject) and distance (front, middle and back rows).

In order to avoid the possible influence of these restraints, subjects had no knowledge about this specific requirement.

Evaluation criteria

The definition of the 'quality' of the results would be determined by the difference between the locations indicated by the subject and the actual position from which the acoustic signal was emitted, the 'target' position. Accordingly, for each emitted stimulus at a specific position, the correspondence of the subject's answer with the correct position or with a deviation from the correct position or 'target' was verified.

As a result of the need to treat data resulting from these tests quantitatively, a scoring scheme was devised as presented in Table 1.

Results

Using these designations and comparing all the subjects' answers with the target positions it was possible to obtain the total number of deviations for each type of HPD and for each parameter analysed. These results are presented in Figure 2.

This shows that, in general, the worst results (higher deviations) were obtained for the distance parameter. For the 'no HPD' and 'earplug' conditions, the deviations are more than double the comparable deviations fro the direction parameter.

Taking into account these values corresponding to the deviations

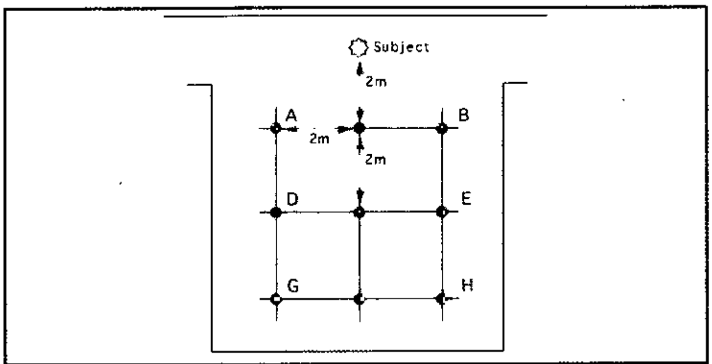

Figure 1

Grid of positions for the auditory stimulus emission

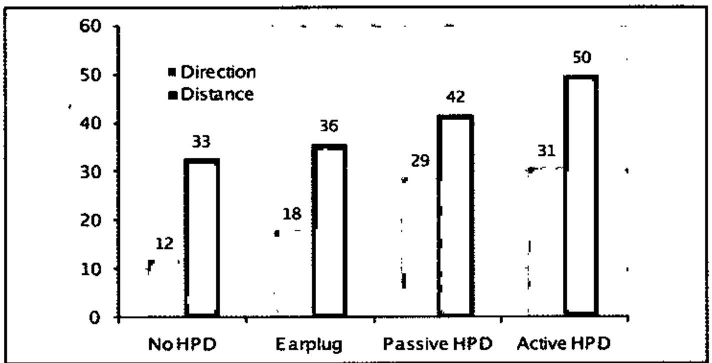

Figure 2

Total number of deviations for the tested parameters

Score	Direction	Distance
0	no deviation	no deviation
1	1 position deviation	1 position deviation
2	2 positions deviation	2 positions deviation

Table 1

Scoring scheme adopted as function of the deviation from the target position

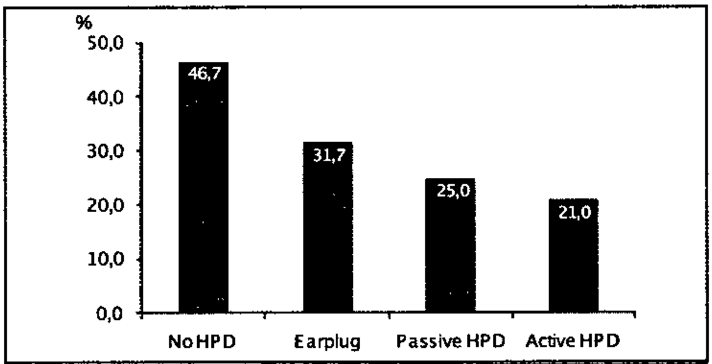

Figure 3

Percentage of answers in the 'target' position

from the target position it is possible to calculate the percentage of responses that indicated the target position (considering simultaneously the direction and distance parameters), and these are presented in Figure 3 for each type of protection condition.

From the results obtained it is possible to observe that again, the best subjects' performance was obtained for the 'no HPD' condition and the worst for the 'active HPD' condition.

Focussing on the deviations obtained, it is possible to identify the main trend analysing the percentage of correct answers according to the location of the target position. This analysis is shown in Table 2.

Taking into consideration the results of Table 2, it seems that for the direction parameter there is a decrease in the target hits in the centre position, for both the 'earplug' and 'no protection' conditions. For both for the 'passive earmuff' and 'active earmuff', there is a gradual increase in performance from left to right.

For the distance parameter, it can be seen that both the 'no HPD' and 'passive earmuff' conditions had the best performance at the back position.

Although there is no immediate and clear explanation for the results described, it is clear that in all of the conditions analysed there is greater difficulty in identifying the target location by distance, especially when the target is located closer to the subject (but this is not true for earplugs). For the direction parameter, it appears that the difficulty arises in the centre but not when the target is located to either side of the subject.

As expected, the best performance (lowest mean deviation) was obtained when subjects did not use any protection at all. Accordingly, and considering the 'no HPD' condition as a baseline, the mean differences between this condition and all the others

parameter	location	no HPD	earplug	passive earmuff	active earmuff
direction	left	91	82	49	40
	centre	70	66	57	42
	right	91	72	74	69
distance	front	40	41	40	28
	middle	31	55	23	32
	back	81	49	62	42

Table 2

Percentage of correct answers according to location of target position

continued on page 32

Auditory localisation of a fork-lift truck - *continued from page 31*

were calculated. Figure 4 presents these differences for both parameters tested.

According to the results obtained, the best performance is achieved with earplugs (lower deviations from the baseline condition and for both parameters), followed by passive earmuffs, and finally active Earmuffs. For both parameters it is possible that the results can be influenced by some contribution from the pinna, which may explain the difference in performance amongst earplugs and earmuffs. An over-the-ear muff may change the sound perception, while an inserted protector will not, or at least, not to a great extent[3].

It is also clear that this decreased order of performance applies to both parameters (direction and distance). Furthermore, the performance is clearly better in terms of determining direction, as the differences for this parameter are smaller in all the protection conditions.

Although the distance parameter has larger deviations for all protection conditions, if the condition of 'no HPD' is taken as a baseline, it can be concluded that the bigger difference occurs when determining the direction, the maximum difference being 0.37 compared with 0.33 for distance.

Because of the nature of the data, a statistical analysis of the results was carried out. This analysis focused on the main aspects that were analysed, namely the two parameters direction and distance of the acoustical signal. Table 3 shows the scores for each condition tested.

In order to examine the hypothetical statistically significant differences among the several tested protection conditions, a one-way ANOVA was applied. The results are presented in Table 4.

From the analysis it can be concluded that there are statistically significant differences (where $p < 0.01$) in the deviation variable across the different protection conditions. In other words, there are significant differences in deviation variable when comparing the use of HPDs of different types, as well as the condition of non-use.

It is also possible to conclude that, for the second parameter (distance), there are statistically significant differences ($p < 0.05$) in the deviation variable.

Although with a lower statistical meaning, it appears that when the distance parameter is considered, there are significant differences in deviation from the target location.

From these differences, it is possible to verify that the best performance (lower deviation) is achieved, as expected, without the use of any hearing protection at all. Comparing the different HPDs tested, it is also possible to conclude that the best performance is achieved with earplugs, followed by passive earmuffs, and the worst with active earmuffs.

It is also clear that the same order of decreasing performance is similar for both direction and distance. It can be seen that the location performance is clearly better in terms of direction, as the differences for this parameter are smaller than the other protection conditions.

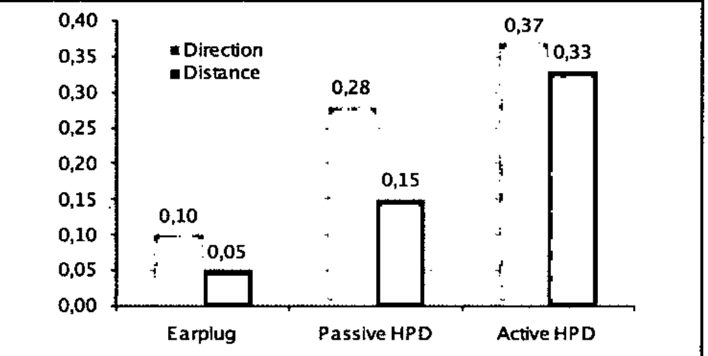

Figure 4

Difference between the mean deviation of each protection condition and the "No HPD" condition

condition	direction deviation		distance deviation	
	m	sd	m	sd
no HPD	0.20	0.48	0.55	0.62
earplug	0.30	0.56	0.60	0.67
passive earmuff	0.48	0.68	0.70	0.67
active earmuff	0.57	0.72	0.88	0.80
totals	0.39	0.63	0.68	0.70

Table 3

Statistics for deviations for each of the conditions tested

variable	df1	df2	F	p
direction	3	236	4.415	0.005
distance	3	236	2.690	0.047

Table 4

One-way ANOVA results for deviations from the 'target' location

Conclusions

Workers tend to complain about the use of HPDs, mostly because they feel that their use impairs or hinders the perception of acoustical signals, in particular acoustical alarms[2].

To a certain extent, the results justify such behaviour, as they are generally consistent with the accepted notion that the use of HPDs will impair the localisation of acoustical sources. However, it should be also noted that even without the use of HPDs there is a natural difficulty in the perception of the distance and spatial location of an acoustic stimulus. This means that the difficulty in locating the auditory stimulus is something that also occurs in subjects with unprotected ears. Hence, it is very likely that the role of HPDs is this issue is sometimes exaggerated by its users. It is also likely that the employees of a particular company can use this argument to justify not using HPDs, even if the real reluctance is related to other factors such as the discomfort caused by this type of protective equipment.

However, as expected, there is a specific impairment in the auditory localisation and distance perception as a result of using HPDs but this impairment exists regardless of the type of protection. This impairment should be considered as a significant risk factor, in particular for situations where the wrong perception of an auditory alarm signal may have serious implications for the workers' safety.

The results show the need for some caution when adopting hearing protection, particularly in acoustical environments where there is a need to identify acoustical signals. In this type of environment, and considering the results obtained in the present study, there is a need to protect workers from noise, but the preferred device would be earplugs. These devices seem to interfere less with acoustical signal perception.

The results are in accordance with previous studies in this topic, which reported that in situations where the identification of an acoustical source is important, the use of earmuffs should be avoided, because of the impairment caused by such devices[7].

When the correct localisation of an acoustical source is important, both in terms of the source distance and direction, and if the use of HPDs is compulsory, workers would benefit from a training programme which will allow them to improve their sensitivity to the specific noise source. Alternatively, acoustical alarms should be implemented together with visual alarms, located in places easily visible to the worker.

Finally, it is expected that this study can be further developed, and it would seem important to include in the sample a group of subjects who have experience of using HPDs in the workplace. When setting up the tests, it would be useful to consider the simultaneous presence of a background noise, which will result in a more realistic approach.

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Lessons learned from acoustic testing in schools in the south-west of England

Thomas A Mitchell. with reference to BB93

Introduction

This article reports on findings from post-construction acoustic testing in over thirty schools in the south-west of England. The acoustic criteria for new school buildings are contained in Building Bulletin 93[1], and include indoor ambient noise levels (arising from building services and off-site noise sources), airborne and impact sound insulation between spaces, reverberation times and speech intelligibility in open plan areas. Each metric is been considered in turn: measured levels of performance are compared with the criteria and design predictions, and conclusions drawn regarding common causes of non-compliance.

Indoor ambient noise levels

Indoor ambient noise levels are heavily influenced by external noise levels, the attenuation offered by the building envelope, and whether the space is mechanically or naturally ventilated. Since 2006, the primary condition under which naturally ventilated rooms must meet the indoor ambient noise limit is with a ventilation provision of 3 litres per second per person[2]; there is therefore a need to consider the effect of open windows or ventilators on noise ingress.

Noise ingress

A large number of internal noise measurements have been conducted with windows closed and mechanical ventilation systems switched off. Whilst this does not represent the ventilation condition under which compliance should be assessed, the results do indicate that in most locations standard double glazing is adequate to control noise ingress. Internal levels of 30dB(A) or below are typical, with levels exceeding 35dB(A) (the limit for general classrooms) only for buildings in close proximity to busy roads. With windows open, internal noise levels were seen to increase by about 10dB at both an urban and a rural site.

Internal noise levels occurring at a ventilation rate of 3 litres per second per person were also evaluated in detail at a site with an external level of 45dB(A). Building Bulletin 93 suggests that if external noise levels are below 45dB(A) no special measures are likely to be necessary to protect school buildings from noise. This was borne out on site, internal noise levels ranging from 22 to 32 dB(A) with windows open to provide 3 litres per second per person (opening areas being calculated using the DCSF ClassVent spreadsheet[3]), and were between 2dB and 15dB lower with windows closed. Comparison of the measured internal noise level and design calculations for a typical classroom showed a discrepancy of less than 1dB. This suggests that simple calculations of noise ingress through unattenuated openings are likely to be reasonably accurate. Calculations were based on the third-octave noise spectrum measured externally, and ingress through the dominant paths only (glazing and ventilation opening, the latter modelled as a hole offering no attenuation), applying the following equation to each frequency band:

$$L_{internal} = L_{external} - R + 10\log_{10}\left(\frac{S}{V}\right) + 10\log_{10}(T) + 11\ \text{dB} \quad [1]$$

where

- $L_{internal}$ predicted internal noise level for the frequency band (dB)
- $L_{external}$ measured free-field external noise level for the frequency band (dB)
- R composite sound reduction index for the building envelope for the frequency band (dB)
- s surface area of the building envelope (m^2)
- v volume of room (m^3)
- T reverberation time of the room for the frequency band (s).

Building services

Mechanical ventilation is frequently presented as a panacea to the problem of noise ingress. There is potential to incorporate acoustical attenuators to control external noise ingress, noise from the air handling unit, and crosstalk between rooms via ductwork. On-site experience has shown a considerable range of outcomes, from noise levels well in excess of the indoor ambient noise criteria (up to 55dB(A)), to systems that remain well below the criteria (down to 19dB(A)). Building Bulletin 93 states that building services should meet the appropriate criterion when operating at their maximum duty.

It was universally found that where ceiling or wall mounted fans had been provided in teaching spaces (classrooms and sports halls), the lack of scope to provide acoustical attenuation led to non-compliant internal noise levels (in the range 45 to 55 dB(A)). Another common source of noise was wall-mounted fan-cooled server racks, located in classrooms or offices. Noise levels of 45dB(A) were recorded in an office, and 33 to 37 dB(A) in music classrooms. It is unclear whether Building Bulletin 93 requires this source of noise to be considered: whilst building services noise definitely falls within its scope, equipment used in the space does not. Server cabinets generally run continuously, are not under the control of the teacher and have provoked complaint in several cases.

Ducted ventilation systems offer scope to provide in-line attenuators. Such systems have been evaluated in a number of music suites, and found to result in compliant noise levels (19 to 33 dB(A)) in music classrooms, ensemble and practice rooms, and drama studios.

Airborne sound insulation

The airborne sound insulation requirements of Building Bulletin 93 depend on the categorisation of the rooms from which and to which sound is transferred. This results in a weighted sound level difference criterion ($D_{nT,(Tmf,max),W}$) of between 30 and 60 dB, after normalisation to assume the maximum allowable reverberation time ($T_{mf,max}$) in the receiving room.

In this article, we address the degradation experienced between the weighted laboratory sound reduction index of a construction (R_W), and a similar figure derived from site measurements (R'_W). This is indicative of the extent to which the theoretical performance of the construction has been reduced by flanking transmission via indirect paths, poor workmanship and service penetrations. Whilst Building Bulletin 93 requires compliance to be demonstrated in naturally ventilated rooms with windows open in both rooms to provide 3 litres of air, per person, per second, the tests analysed here were conducted with windows closed. The effect of flanking via window openings is considered separately below.

Wall constructions

Figures 1 and 2 compare the in-situ and laboratory performance of masonry and stud partitions respectively. The walls did not contain doors or windows, and were tested with windows closed in both rooms. Points lying below the diagonal line have experienced on-site degradation. Performance of similar constructions was found to vary markedly between sites, and in many cases the 45dB $D_{nT,(Tmf,max),W}$ required between classrooms was not achieved. Investigation of cases of poor performance revealed that unsealed service penetrations concealed above tile in grid ceilings, flanking via lightweight metal roof constructions and poor sealing of the wall-roof joint (particularly to profiled liner trays) were common causes of degradation. Other examples show that with appropriate workmanship and flanking details, high levels of performance can be achieved with little degradation from the laboratory figure.

An interesting comparison was possible at two music suites built to the same design with timber stud partitions. One incorporated resilient metal bars in the walls and the other did not. The laboratory R_W of the walls was predicted to improve from 48dB to 56dB with the bars present; similar levels of performance were measured on site (46dB and 56dB respectively).

Floor constructions

Figure 3 compares the measured and predicted weighted sound reduction index for a number of constructions. Points lying below the diagonal line have

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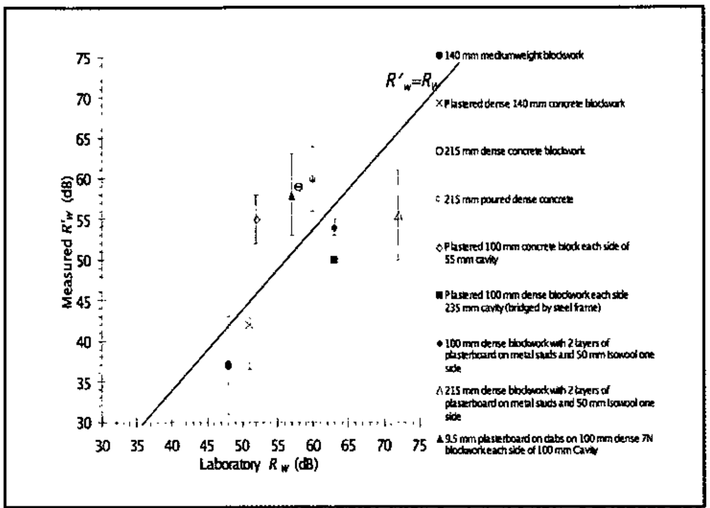

Figure 1

Comparison of measured and laboratory performance of masonry wall constructions (vertical bars indicate range of measured values)

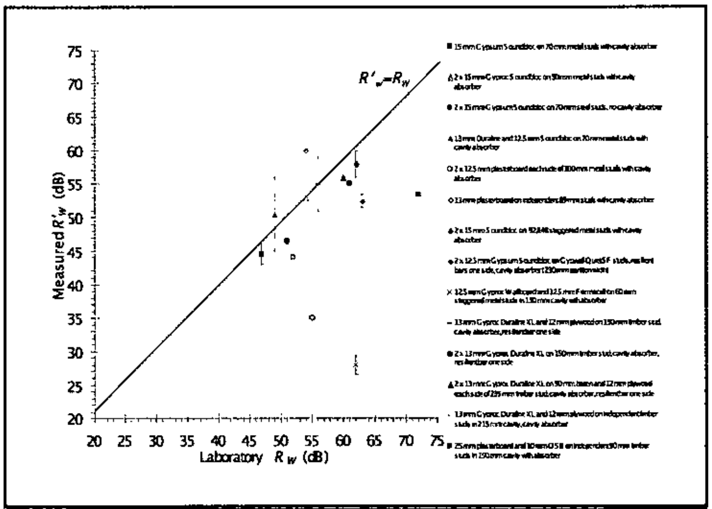

Figure 2

Comparison of measured and laboratory performance of stud wall constructions (vertical bars indicate range of measured values)

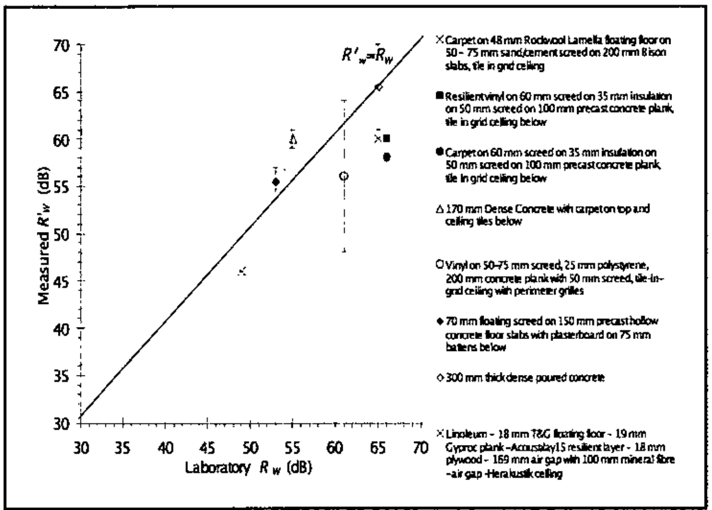

Figure 3

Comparison of measured and laboratory performance of floor constructions (vertical bars indicate range of measured values)

Lessons learned from acoustic testing in schools - *continued from page 34*

experienced on-site degradation. In all cases the measured weighted level difference ($D_{nT,(Tmf,max),W}$) met the 45dB criterion that would pertain between two classrooms. Despite these tests being conducted in the same buildings as the horizontal airborne sound insulation measurements, there are few cases of severe degradation. This may be attributable to the heavyweight masonry constructions and less scope for concealing unsealed joints and holes than is the case with walls above suspended ceilings.

Doors and folding partitions

The sound insulation performance of doors and folding partitions rarely comes close to that of a medium specification wall construction, owing to the difficulty of providing a reliable seal between the movable components. Doors and folding partitions directly linking teaching spaces are frequently specified in schools to make the accommodation more flexible.

Estimation of the sound insulation performance of standard one-hour timber fire doors equipped with proprietary acoustic perimeter and threshold seals from site tests suggests that an R'_W exceeding 30dB is rarely achieved. An R_W of 30dB is the requirement for doors between classrooms and corridors: when fitted between classrooms there is little chance of the sound insulation requirement being met. Folding partitions can be obtained with laboratory R_W ratings up to about 55dB. However, the measured performance over a number of schools ranged from the high twenties to the low forties. Both door and folding partition performance was found to be highly prone to the tolerances achieved on site, and is likely to degrade as seals wear and settlement occurs.

The flanking path between rooms via entry doors and the corridor has arisen as a limiting factor for sound insulation between music suites, where the separating partition and other flanking details are to a high specification. The sound insulation performance requirement between such rooms is 55dB, and it was found that with doors equipped with acoustic seals (estimated R_W 30dB), sound insulation between rooms was falling just short of the requirement. Taping the perimeter and threshold of the doors effected an improvement of about 4dB. The spacing between access doors varied between practice rooms, and increasing the distance between doors effected a significant improvement (Figure 4).

The effect of open windows

At five sites, sound insulation tests were repeated between several rooms with windows open and closed. Furthermore, for one pair of rooms the effect of different window opening distances and spacings between windows was examined in some detail. In all cases, windows were top-hung - a typical configuration in new British schools.

A clear trend emerged. If, with windows closed, the R'_W exceeds 50dB, opening windows causes a significant degradation in sound insulation performance (the R'_W is typically reduced by 10dB). If the overall R'_W is less than 50dB with windows closed, degradation was limited to 3dB at most. It is logical that this relatively tortuous path for sound transfer becomes more significant as the sound insulation performance of other paths is increased.

Estimating the effect of flanking via window openings at the design stage, as is required to demonstrate compliance, is problematic. There do not appear to be established empirical equations to take this factor into account, and complex geometric modelling is probably not feasible on such projects. A comparison of the degradation experienced on site with the predicted effects of a hole linking the two spaces, or prediction of noise egress to a point outside the window, then ingress from this point into the adjacent room, showed both of these approaches to be excessively pessimistic. This is because the tortuousness of the path is not taken into account. However, the following rules of thumb are proposed.

1. Minimise the required area of opening required to provide a given ventilation rate, by providing cross-flow ventilation. A large physical area of opening may need to be retained to alleviate summertime overheating.
2. Maximise the distance between opening windows in adjacent rooms (again, it may be desirable for all windows to open, but the use of certain windows first (by signage or provision of mechanical actuators and automatic control) could be encouraged. Figure 5 shows that a strong trend was witnessed on site between the proximity of openings and the degradation in sound insulation.

Impact sound insulation

Impact sound insulation measurements are conducted using a standard tapping machine, and the resultant noise level is measured in the room below. The results can be compared with laboratory ratings or estimates for the construction, to indicate the degree to which service penetrations and flanking transmission have degraded the expected performance.

Figure 6 compares the measured and predicted normalised impact sound level ($L_{n,W}$) for a number of constructions. In all cases the measured standardised impact sound level ($L'_{nT,W}$) met the 60dB upper limit for transmission into a classroom. As with the airborne sound insulation performance of floors, the level of degradation experienced on site is relatively small (points lying above the diagonal line have experienced on-site degradation).

Reverberation

Classrooms

Measurements of reverberation time in a large number of classrooms have shown that the mid-frequency average criterion, T_{mf}, was consistently met where a significant area of highly sound-absorbent surface had been provided. This provision normally took the form of a sound-absorbent tile-in-grid ceiling, although rooms with perforated roof liners, open slatted wooden ceilings with absorbent quilt behind, or perforated plasterboard ceilings also featured. In most cases the results met the reduced criterion for primary school classrooms (0.6s *cf.* 0.8s), and rooms with highly absorbent ceilings, carpets and moderate ceiling heights (<3m) generally met the 0.4s limit for rooms specifically for use by hearing impaired pupils.

It should, however, be noted that the measurements were conducted in fully commissioned schools, in furnished rooms. The criteria apply to unfurnished rooms. The presence of furniture will help to scatter sound and break up flutter echoes that would accentuate the reverberation time in a bare room, particularly where most of the sound absorption is provided on one or two planes (the case with a sound-absorbent ceiling and carpeted floor, for example). Furthermore, some of the primary school classrooms contained extensive artwork and wall displays, which may have provided additional sound absorption. At one school the opportunity arose to repeat measurements several times during the first year of occupancy. The reverberation times typically reduced by 0.2s or less (from 0.8s initially) over this period.

Cases of excessive reverberation time have been identified in classrooms where highly sound absorbent surfaces have not been provided. These classrooms either had plasterboard ceilings or unperforated metal roof liners (ceiling heights varied from 2.4 to 5 m). T_{mf} values were typically in the range 1.0 to 2.0 s for rooms with a hard floor finish, higher values arising in rooms with an increased ceiling height. Carpeted rooms with ceiling heights at the upper end of this range had reverberation times of 1.2 to 1.4 s. These conditions frequently led to complaint and the need for remedial treatment. It was found that rooms with low ceilings (2.4m) and carpets typically returned T_{mf} values of 0.5 to 0.6 s, indicating that in classrooms with low ceilings and carpets additional sound absorption is not necessary.

Prediction of reverberation times in classrooms using the classical Sabine formula has usually proved accurate to within 0.2s, in comparison with the unoccupied, furnished condition. It is important to ensure that the area of absorption modelled matches that specified; it is easy to overlook the area occupied by light fittings and air transfer grilles in tile in grid ceilings, and plain plasterboard bordering of perforated plasterboard ceilings.

Large spaces

Large spaces such as sports halls, multipurpose halls, atria and drama studios have been encountered with reverberation times well in excess of the permitted maxima. The success of providing highly sound-absorbent finishes to the ceiling and upper parts of walls has been found to be mixed. Such spaces are often used with sparse furnishings, and this makes the effect of flutter echoes a real problem.

In primary school halls, reverberation times of up to 3.4s have been measured in spaces with no specific provision of sound-absorbent surfaces. Similar spaces with a sound-absorbent ceiling finish were in the range 0.9 to 1.7 s. The success of such treatment was seen to correlate with the amount of scattering offered by wall-mounted equipment and perturbations, such as climbing bars, door and window recesses, masonry columns and boxed-in steelwork.

Large secondary school sports halls have been measured with reverberation times of up to 6.5s. In the worst cases, no specific provision of sound-absorbent surfaces had been made. Retrofitting of wall and ceiling-mounted absorber has met with mixed success. In one case, examined in detail, a tile-in-grid ceiling lining was fitted and sound-absorbent panelling placed on the upper walls. With

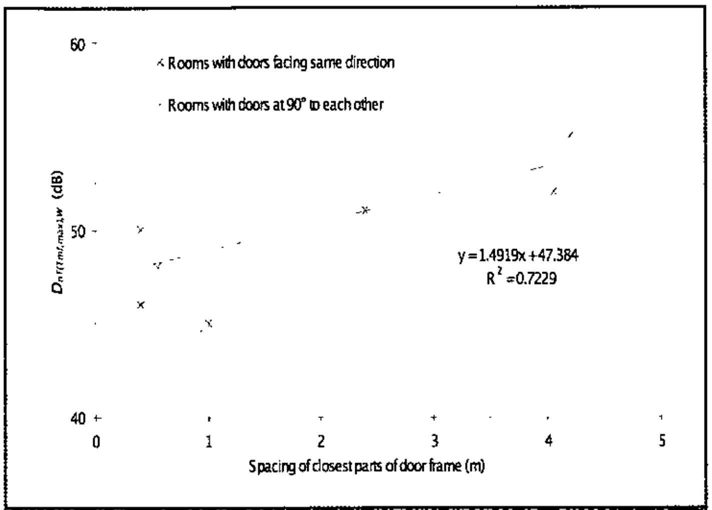

Figure 4

Effect of door spacing on sound insulation performance between music practice rooms. Rooms with doors at 90° to each other have been excluded from the regression analysis

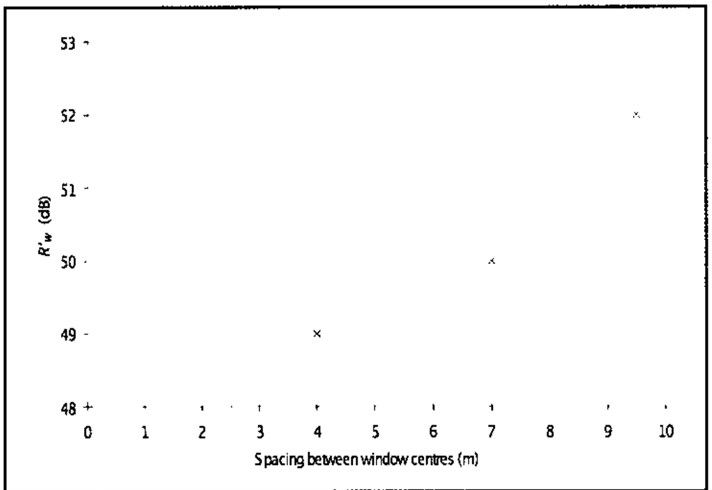

Figure 5

Effect of window spacing on sound insulation performance between two classrooms. Windows were open 20mm at their bottom edge (resulting in a $0.033m^2$ opening at the bottom and $0.0015m^2$ each side). The R'_W was 53dB with windows closed

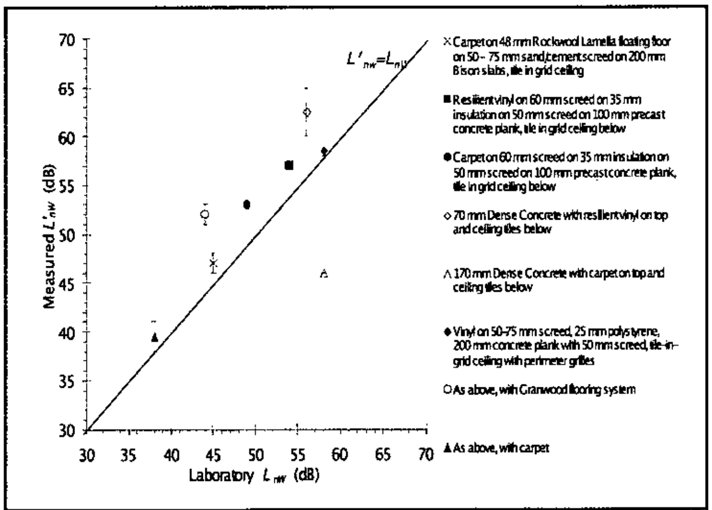

Figure 6

Comparison of measured and laboratory performance of floor constructions (vertical bars indicate range of measured values)

plastic and metal chairs and tables in the room, the reverberation time was reduced from 2.0 to 1.2 s, but with no furniture the reverberation time post-treatment was 2.8s, significantly worse than that before treatment.

Sabine formula predictions of unoccupied, unfurnished large spaces have been found to under-predict significantly the reverberation time owing to the effects of flutter echoes in these spaces. This can lead to design or remedial strategies being adopted that will not be successful when the space is used by a small number of people with sparse furnishings. Ray tracing modelling of these spaces (using the commercial software *CATT Acoustic*) has been found to be far more accurate, predicting reverberation times well in excess of the Sabine prediction and close to measured unoccupied, unfurnished values.

Speech intelligibility

Speech intelligibility tests were not conducted in open plan spaces at any of the sites. However, a site assessment of the effectiveness of classroom soundfield systems showed that if the measured unoccupied STI scores were adjusted to assume a typical background noise level of 52dB(A), the average STI score ranged from 0.34 to 0.48 over the ten rooms evaluated, and the minimum STI scores ranged from 0.27 to 0.42. These pertained to traditional teaching configurations with the teacher addressing the class from the whiteboard. The rooms did not exceed 8 metres in any dimension, and covered a range of acoustic conditions, some incorporating highly sound-absorbent ceilings. For open plan teaching, Building Bulletin 93 requires an STI of above 0.6. These results suggest that with the higher level of background noise to be expected in open-plan spaces, medium range communication (over several metres) will be difficult to achieve. This may not, however, be necessary if children are generally addressed over short distances in small groups.

Conclusions

Results from acoustical testing in schools have revealed the following common problems and possible solutions.

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Lessons learned from acoustic testing in schools - *continued from page 37*

- Noise ingress is highly site-dependent. Ingress with unattenuated natural ventilation can be minimised by providing cross-ventilation to reduce the areas of opening required. Modelling open windows as non-attenuating holes matches well with site measurements.
- To be compliant, mechanical ventilation systems need to incorporate appropriate levels of acoustic attenuation. Wall or ceiling-mounted fans are unlikely to comply.
- The degradation experienced from the laboratory performance of walls varied significantly, depending on flanking details and whether service penetrations had been adequately sealed (including those concealed above false ceilings). Fewer cases of significant degradation were identified for the airborne and impact sound performance of floors, possibly since penetrations cannot be concealed at the floor surface.
- Doors are a weak point for noise transfer. Where high levels of performance are required, flanking transmission via the corridor can be significant and doors should be spaced as widely as possible. Flanking transmission via open windows appears to become significant when the R'_W with windows closed exceeds 50dB. Again, increasing the distance between openings is beneficial.
- Except for rooms with a minimal ceiling height and carpet, a highly sound-absorbing surface is required in classrooms. The Sabine formula predicts the furnished reverberation time reasonably accurately, but severely under-predicts the reverberation time of school halls with sparse furnishings and ceiling-mounted absorber.

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This article is closely based on the paper he presented at Euronoise 2009, Edinburgh.

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Public acceptance of helicopters

John W Leverton. **The virtual noise component**

Introduction

The development of helicopter operations in many parts of the world and particularly in Europe and North America is being restricted by objections about noise. The development of new heliports, and changes to services at existing facilities, tends to be controversial and is often rejected as a result of public opposition. Prime examples are the continuing debate about helicopter operations and heliport development in London[4], the use of heliports in New York[5] and helicopter sightseeing tours of the Grand Canyon[6]. This issue is also addressed in a report on non-military helicopter noise to the US Congress by the FAA[7] and in a more recent study in the UK for Department for Environment, Food and Rural Affairs (Defra)[8].

The reasons for the apparent disparity between the reaction to helicopters and that of other forms of transport are addressed in this paper together with a consideration of what is different about helicopters, and what singles out helicopters for special attention.

Social survey results

A review of case histories, press reports and information collected by industry associations makes it fairly clear that helicopters and heliports in many locations have a low level of public acceptance. This was put into perspective a number of years ago when the results from a number of studies connected with the operation of helicopters in the United Kingdom were reported in 1993 by the Civil Aviation Authority (CAA)[9]. Figure 1, reproduced from this report, shows annoyance as a function of noise level expressed in terms of $L_{Aeq,16}$ hour. The noise metric L_{Aeq} expresses time varying A-weighted noise levels occurring during an observation period as a single constant value having the same acoustic energy. The 16-hour period from 07:00h to 23:00h is used for planning purposes in the UK. This metric is similar to the Day-Night Average (L_{DN}) metric used in the United States.

In the 1982 survey, data was obtained by the CAA along the route of the Gatwick-Heathrow Airlink service (no longer operating) and at Aberdeen,

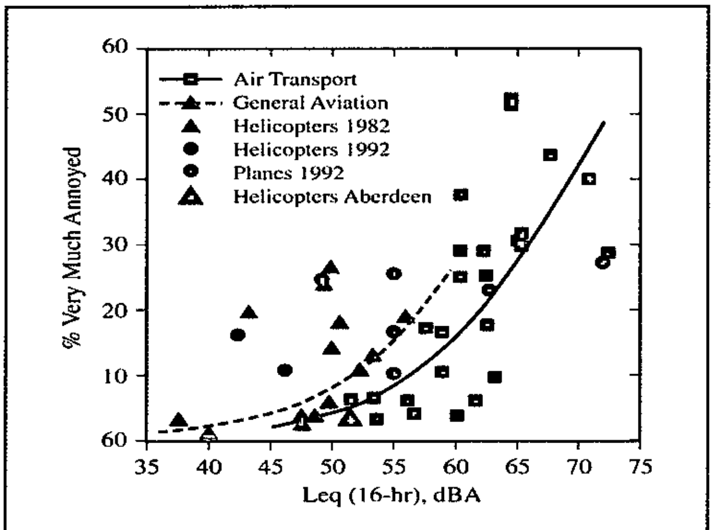
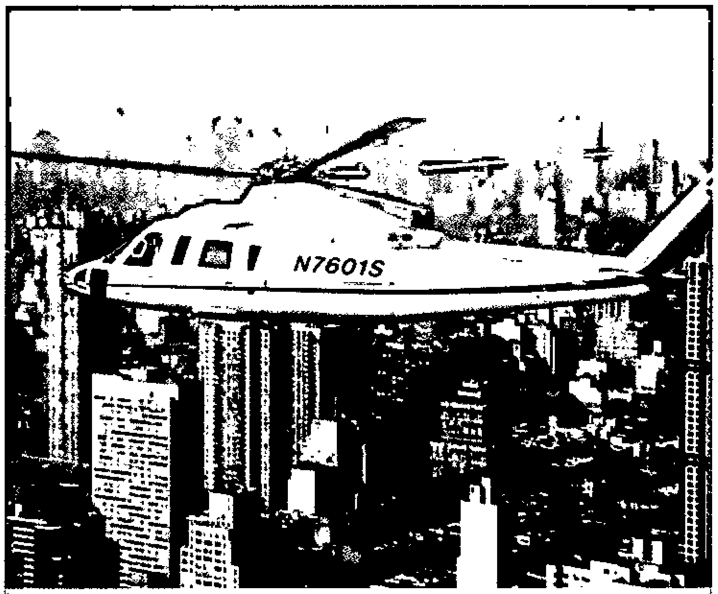


Figure 1

UK CAA social survey results



The perceived intrusion of the helicopter into living space because of low flying is a significant negative factor

Scotland, the major base for offshore oil industry helicopter operations in the North Sea. Figure 1 reveals that, relative to air transport (fixed wing) aircraft, helicopters operating in the London area were considered to be up to 15dB more annoying, in terms of the A-weighted level, at the 10% and 20% *very much annoyed* level. The helicopter results contrast with those obtained in Aberdeen which showed no difference from fixed-wing aircraft. Ollerhead[9] suggested this disparity in reaction could be explained in socio-economic terms: '*Better off people tend to be more annoyed*'. Moreover it was believed that residents under the Airlink were disposed less favorably towards a helicopter shuttle service which was being used largely by first-class passengers, whilst in the Aberdeen area, North Sea oil operations contribute significantly to the local economy.

In 1992 a small-scale study was performed by the CAA[9] in London, at Fulham and Putney, and along the River Thames in the vicinity of Battersea and near one of the London Helicopter Routes. The results were similar to those for the Gatwick-Heathrow Airlink evaluated ten years earlier (Figure 1). The London flights were dominated by the corporate market using light and medium helicopters including a large number of Bell Jet Rangers and Long Rangers plus Aerospatiale (now Eurocopter) Dauphins, Sikorsky S76s and a few larger helicopters. Studies carried out by the Greater London Council in the same time frame also confirmed an underlying concern of the residents about noise and safety of helicopters.

The public have major concerns about safety issues and often do not fully understand the need for helicopter operations

Noise complaints

Results similar to those obtained in London are common whenever helicopter complaints are examined. Analysis of the noise complaints also reveals a strong connection between noise and safety and the perception about safety plays a significant part in public reaction towards helicopters which has a direct bearing on the level of acceptance.

Another common misconception which influences the public attitude is that helicopters generally fly in an uncontrolled manner and the national authorities have little or no power over the flight paths or heights used. This is not correct, particularly in metropolitan environments in the US, Canada or Europe, but such misconceptions seem to be deeply rooted. A 1987 study for the AHS[10] reported that '*the perceived intrusion of the helicopter into one's living space as evident by low flying is a significant negative factor*'. Another important issue is that of the low flyover height used by many helicopters, particularly in the USA. A study11 made in Hawaii in 1994 as a result of the anti-tour helicopter lobby stated that people in rural areas felt that their home's privacy was invaded by helicopter flyovers. From these and other statements there appears to be a strong commonality in the response to helicopter noise irrespective of location or country being considered. Assessments also suggest that there is a strong relationship between the number of flights and the level of annoyance with an upper limit of just four or five flights per day before the annoyance becomes, in terms of the public, unacceptable[11].

The magnitude of such negative response to helicopter operations as a result of noise is, on the surface, difficult to understand because most helicopters generate noise levels considerably below the internationally agreed noise certification limits and comfortably satisfy established community noise rating criteria and guidelines. The inference is that even relatively sophisticated noise rating methods based on complex objective measurements fail to account for the disturbance caused by helicopters. As a result of concerted opposition to helicopter operations it has been suggested that the noise criteria and limits associated with community rating procedures should be made more stringent. Although minor adjustments to the assessment criteria may be helpful, analysis of the issues indicate that such action will have little or no direct effect on the level of public acceptance. For example, a comprehensive study[12] of helicopter operations at a military airbase in the UK concluded that there was no meaningful correlation between the absolute helicopter noise levels and subjective annoyance. The authors of the study commented that the results confirm, for helicopters, the weak relationship between objective noise measures and subjective annoyance. Significantly, the same rating methods are generally considered to be successful in controlling the environmental impact of large commercial aircraft and other forms of transportation so there appears to be something different about the way in which helicopters are perceived.

Also, if noise complaints associated with helicopter operations are examined it will often be seen that small helicopters, which generate low overall noise, will provoke at least the same level of complaints as larger helicopters which produce much higher noise levels. Thus there is not a strong link between the maximum or peak noise level and public acceptance.

Another aspect which soon becomes clear when examining noise complaint information, and from talking to those involved, is that the character of the helicopter sound is a very important factor. The more impulsive the sound, or the more tonal noise or 'whine', the more likely are complaints to occur. In addition, it also soon becomes clear that these features are important when the helicopter is first heard and the actual sound level is 25dB lower than the maximum noise level which occurs during a flyover or fly-by, or even less. Unfortunately there is no known or generally agreed way to take these aspects of the sound into account.

Public acceptance

Community noise rating procedures are considered to predict the impact of fixed-wing aircraft noise around airports and within local communities relatively well. This is not the case for helicopters and heliports, which appear to create a level of adverse reaction disproportionate to the measured or predicted noise levels. A partial explanation for the disparity between noise assessments and community reaction to helicopter operations has been identified[1,2,3] as deficiencies in the rating methods. For a more complete analysis of the issues it is necessary to examine the way in which helicopter operations are perceived. Fixed-wing aircraft operations at airports typically involve a large number of flights per day and, because the noise characteristics of most of the large jets are similar to one another, the noise climate is relatively uniform.

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Public acceptance of helicopters - *continued from page 39*

Away from airports aircraft fly at very high altitude so noise levels on the ground are low. In addition, there is little concern over aircraft safety. Helicopter operations are very different. In general, the flight paths, unlike those used by fixed-wing aircraft, vary widely and so at any one location the noise pattern is much less consistent. There are also very large differences in both level and, more importantly, the character of noise created by different helicopters with some small helicopters often *sounding noisier* than larger ones. Over-flights are also generally made at relatively low altitudes so that any concerns over safety are heightened.

Acoustical (direct noise) stimulation

A generalised A-weighted sound pressure level time history of a helicopter flyover is shown in Figure 2 to illustrate the influence of various noise sources on overall noise level. The principal sources are main rotor thickness/high speed impulsive noise (HSI), main rotor blade/blade vortex interaction noise (BVI), main rotor wake/tail rotor interaction noise (TRI) and tail rotor noise (TR).

HSI, TRI and TR noise are most pronounced during flyover. BVI noise is normally the dominant source during descent (landing) although TR and TRI noise can also be present. BVI can also occur on some helicopters during flyover and cruise flight and it is pronounced during banked turns. In the case of tandem rotor aircraft, BVI occurs continuously, regardless of flight condition. Most importantly, it can be seen that the greatest effect of the intrusive sources occurs more than 10dB below the maximum value so they will have little or no influence on time integrated units such as sound exposure level (SEL) and effective perceived noise level (EPNL).

The idealised upper trace shown on Figure 2 represents a flight during which the impulsive sources are generated continuously. However, these sources often occur intermittently in which case the time history would exhibit relatively rapid increases and decreases in level. BVI and TRI are also particularly sensitive to control inputs and changes in wind speed and direction. These changes in noise level will be more marked on higher speed rotors simply because the sources are naturally more intense. From a subjective point of view the intermittent generation of the intrusive sources is equally or more annoying than if the sound occurred continuously, and tends to draw immediate attention to the helicopter. This is important when considering annoyance.

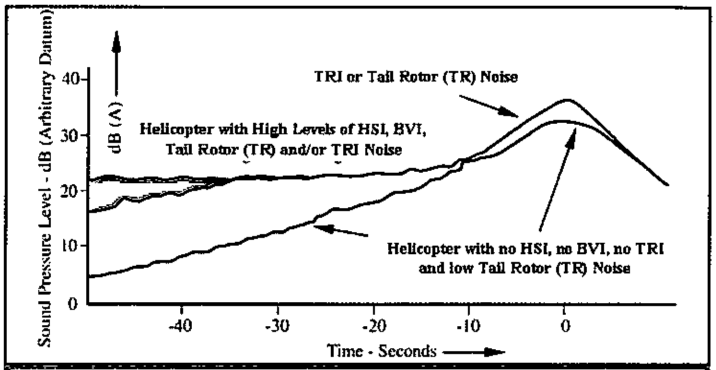

Figure 2

Generalised flyover time history in dB(A)

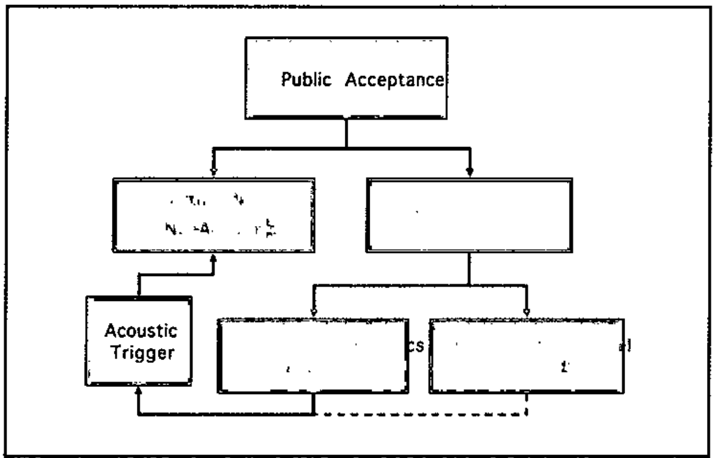

Figure 3

Elements of public acceptance

Annoyance stimuli

Assessments of surveys conducted in London and Los Angeles by the author and Tony Pike for GKN Westland Helicopters (now Agusta Westland) together with information in the files of the HAI and general experience of the industry makes it clear that the subjective impression created by the impulsive noise sources is very important when considering public acceptance. Moreover, except in the case of tail rotor noise (TR), the sources of interest are mainly detected at levels well before the 'minus 10dB down point' ie the position on the sound pressure level time-history at which the level is 10dB below the maximum or peak level.

A study of the various factors involved shows that the level of public acceptance can be considered to be a function of both acoustical (direct) noise and a non-acoustical element, termed *virtual noise*, as illustrated in Figure 3.

The response to acoustical noise is a function of maximum noise level as defined by objective measurements and the subjective characteristics of the noise as it first becomes audible. The magnitude of the non-acoustical component or virtual noise is not related directly either to the absolute level or to the character of the noise generated by helicopters, but it is triggered by the direct acoustical signal.

Even so, the annoyance or level of public acceptance is usually quantified using measured noise levels as illustrated in Figure 1. Consequently the virtual noise element is treated, for all practical purposes, in the same way as the direct acoustical energy (noise) radiated by the helicopter.

There are some situations in which resistance to helicopter operations occurs even though the relative levels of helicopter and ambient noise suggest the helicopter should not be audible. It would seem that in these situations the trigger for the virtual noise is visual. The surprise of suddenly seeing a helicopter, even when it cannot be heard, has been commented upon a number of times by the general public and may offer a partial explanation for concerns about sightseeing operations around the Grand Canyon and New York. The number of occurrences when the visual trigger is significant, however, appears to be extremely small, so the topic is not addressed further in this article.

It cannot be stressed highly enough that whenever adverse reaction to helicopter operations results from virtual noise, attempts to address the problem by reducing noise at source will be largely ineffectual.

It is not simply that the level of sound, at long range as the helicopter approaches or flies towards the observer, are higher than on helicopter models with little or no noticeable HSI, tail rotor (TR), TRI, or BVI noise, rather it is that the *tonal* and *impulsive* characteristics of these sources are in themselves more annoying and draw attention to the helicopter. Some rating criteria apply a +5dB or +10 dB penalty to account for the extra disturbance if a tone or whine, similar to the sound generated by the tail rotor, is present in the acoustical (noise) signal. Many researchers argue that EPNL, and by implication the SEL, L_{DN} or L_{Aeq} metrics, give a realistic measure of both the source level and public response, implying that any increase in the sound associated with BVI, HSI, TRI and tail rotor noise is accounted for in full by metrics which take into account the duration. This however is not supported by the evidence.

The subjective rating of helicopter noise was investigated thoroughly in the late 1970s and early 1980s. One objective was to develop an impulsive correction that could be added to more conventional metrics to account for the subjective effect of BVI and tail rotor noise. Despite the considerable effort expended, the results of these studies in combination were considered by many to be largely inconclusive. After an extensive review of all the issues, the International Civil Aviation Organisation (ICAO) chose in 1983 to use EPNL for helicopter certification, with the proviso that manufacturers should strive to eliminate intrusive noise sources.

Even so, in the context of adjustments to account for high levels of tail rotor and impulsive (BVI) noise it is worth noting that a review[13] of the response of the general public to various noise source associated with military bases and operations, and the current 'adjustments' defined in the International Organisation for Standardisation (ISO) and the American National Standard Institute (ANSI) standards for various noise sources, concluded that the following corrections should be applied.

- Highly impulsive sound + 12dB
- Regular impulsive sound + 5dB
- Prominent discrete tones + 5dB

These adjustments are to be added to measured or predicted day-night-average sound levels (DNL/L_{DN}) used in the USA but the values suggested are equally applicable to any of the standard noise metrics and agree well with the values determined by studies at Westland Helicopters[14,15] in the late 1970s. It is apparent that both the level and character of sound audible at distances greater than those involved in EPNL calculations play a major part in the rating or acceptance of helicopter noise by the general public. The tonal and impulsive quality of sound 15 to 25 dB below the maximum A-weighted noise level observed during any single event can influence the subjective response. It would appear that when the degree of blade vortex interaction (BVI), high speed impulsive/thickness noise (HSI), tail rotor interaction noise (TRI) and/or tail rotor tonal noise (TR) is pronounced these distinctive sources act as an audible cue, increasing the negative response to helicopter noise. These low level triggers are not accounted for in EPNL or SEL calculations which only accounts for acoustical energy within -10dB of the maximum value.

Non-acoustical (virtual noise) stimulation

Virtual noise is dependent on a wide range of inputs but is triggered initially by any distinctive feature of the acoustical signature and, to a far lesser extent, the absolute noise level. The studies based on UK data, supplemented by information from other locations, including that associated with Airspur who operated in the Los Angeles, California area in the early 1980s, show that the noise characteristics and virtual noise are of equal or even greater importance than the maximum noise level observed during a particular flyover or flyby event. It is difficult to ascertain precise values for these components because they are partly interrelated. For example, a helicopter generating BVI or HSI noise may cause annoyance directly, while at the same time acting as a trigger to highlight public opposition to some other aspect of the operation. The information available also suggests that sounds such as tail rotor whine or main rotor impulsive noise or both (BVI and HSI) also exacerbate concerns over the safety of the helicopter because the 'sound' may suggest (falsely) mechanical problems or conjure up an image of a helicopter crashing - as often seen on television.

In the context of this evaluation it has been found that general aviation light propeller-driven aircraft have a similar impact - at least in Europe. Research reported to ICAO based on studies conducted at the Institute of Sound and Vibration Research (ISVR)[16], University of Southampton, has shown that a number of complaints attributed to the noise from general aviation aircraft are, in fact, related to other causes. This research attempted to classify complaints and to quantify the effect in terms of the equivalent A-weighted sound pressure level, with the following results.

a) negative reaction to leisure flying + 5dB

b) poor community/airfield relations + 10dB

c) fear of crashes + 10dB

d) nobody acts on complaints + 20dB

e) aircraft are flying too low + 20dB

It should be noted that these equivalences are not reversible, so that, for example, reducing noise levels by 10dB overall will not remove the fear of crashes.

It is also interesting that while the ISVR study[16] was made at general aviation airfields dominated by light propeller driven aircraft, there was some helicopter traffic at one of the airfield sites studied. Examination of the results obtained indicates similar trends for both general aviation fixed-wing aircraft and helicopters, but it is difficult to be specific because the survey did not set out to highlight differences between helicopters and other forms of air traffic.

While it has not yet been possible to determine similar equivalence factors in such a precise manner, a review of other evidence suggests that the light aircraft findings are generally applicable to helicopter operations. The main difference being that the first of the non-acoustical factors - negative reaction to *helicopter* flying - appears to be stronger than for general aviation aircraft and may be as high as 15dB at particularly sensitive locations. This is because the public at large often perceive helicopters to be engaged either in leisure flying or operating for no justifiable reason. As explained previously, however, if it is believed that helicopters provide a worthwhile service, as in the North Sea, the virtual noise factor can be very low or zero. Similarly, the concern over safety and fear of crashes in areas where flights are conducted over precise routes under air traffic control may be much less. Experience from Aberdeen, where helicopters have become accepted much in the same manner as large fixed-wing transport aircraft, and in the Victoria/Vancouver area of Canada, where Helijet operates a scheduled passenger helicopter service, supports this view.

Amongst the non-acoustical sources associated with airfield related disturbance, the work reported to ICAO[16] found that fear of crashes was the most significant factor. Low flying, changes in the noise signature of the engine, and previous crashes all increased anxiety. At one airfield where an accident had occurred shortly before the survey, concern was almost three times greater.

'Startle' effect

In order to further understand the aspects which influence virtual noise, some of the information in the HAI Acoustic Committee files, for the period 1988/1998 related to US operations, was re-examined by the author. In addition information from three public hearings relating to a heliport application in northern Virginia was studied. This highlighted an additional effect related to the sudden occurrence of the sound of the helicopter, which can be best described as a startle effect, when the helicopter flies over. This appears not only to increase the annoyance, but raises concern to many on the safety of the operation. This was not apparent when a detailed review of complaints related to operations in the UK was conducted a number of years ago. This may be partly explained by the fact that in general the flyover heights used by helicopters are higher in the UK than in the US, and thus the occurrence sound of a helicopter is less sudden. In the UK, the regulations require over-flights to be made at 2000ft unless specific ATC considerations dictate lower heights. On the other hand although some operators in the US use such heights, many operate at much lower heights of 500ft, and even lower heights are not uncommon in some cases. The duration and hence the 'sharpness' of rise and fall of the acoustical signal - startle effect - will be much greater with helicopters flying at lower altitudes. Conversely the higher the flyover height the lower the maximum noise level and the longer the duration of the signal heard on the ground, and hence a decrease in the startle effect.

The lack of quantitative data makes it impossible to draw any specific conclusions. Nevertheless it is postulated that the startle effect is a significant contribution to the virtual noise component and to the perceived safety of helicopter operations in many operations where low (500ft or less) flyover heights are involved. Somewhat ironically, this effect is likely to be more

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Public acceptance of helicopters - *continued from page 41*

pronounced as noise levels are reduced and more especially with significant reductions in the long range cues such as HSI, BVI and TRI noise.

Reduction of virtual noise

Virtual noise can be effectively eliminated by removing the stimuli by which it is triggered. This ideal is normally not achievable on a real helicopter so the aim should be to minimise the effect as far as possible. The study reported here has confirmed that the public have major concerns about safety issues and often do not fully understand the need for helicopter operations. Equally, the helicopter industry often underestimates the level of public apprehension and fear of accidents. Difficult situations are compounded if the community believes responses to complaints are either unsympathetic or dismissive. Problems exacerbated by a lack of diplomacy or tact mean that this virtual noise element can be equivalent to a 15dB or more increase in the perceived A-weighted noise level.

Even with action to understand complaints and associated concerns, the industry will still be faced with two major issues: firstly the fear of accidents, and secondly the lack of appreciation by large sections of the population of why helicopters are required. These virtual noise elements, which evidence suggests can amount to 15 - 20 dB overall, can be resolved only by publicity campaigns. It is unlikely that these two issues can be tackled piecemeal by individual operators, so the combined efforts of the European Helicopter Association (EHA), the AHS International, the Helicopter Association International (HAI) and other associations and societies worldwide are required. The HAI '*Fly neighborly*' programme, targeted at reducing nuisance by encouraging the use of noise abatement procedures, has shown that such concerted action can be very effective. Publicity aimed at highlighting the actual high levels of in-flight safety is also required if virtual noise is to be reduced. To achieve the desired reduction of non-acoustical sources the industry may, however, have to accept tighter operational control particularly in city environments.

Since it is such a strong component of public acceptance, there is great potential for improving the current situation if virtual noise can be reduced or eliminated by better public relations. A satisfactory situation in the broadest sense cannot be achieved until both sides appreciate and understand the concerns and needs of each other. The industry for its part must identify noise-sensitive sites and alleviate problems by re-routing, increasing flyover heights, and revising operational procedures to resolve local noise issues.

A concerted effort by the manufacturers and the industry associations could dramatically reduce the non-acoustical component over a two to three year period. Conversely, there is sufficient evidence to conclude that if no action is taken, virtual noise will remain a highly significant factor in determining the degree of public acceptance of helicopter operations.

Concluding remarks

The reaction to helicopters and heliports is dependent on several factors, some of which are completely unrelated to the sound generated by the helicopter. These non-acoustical phenomena described collectively as virtual noise are usually triggered by acoustical noise although there is some evidence of a visual trigger. The non-acoustical component can be more important than the actual level of the helicopter noise and often dictates the level of public response to helicopters. In addition it appears that the 'startle effect' resulting from low level flyover also contributes to annoyance at, and perceived safety of, helicopter operations where such flights are used and/or allowed.

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This article is based on papers published jointly by the author with A (Tony) C Pike in 1998[1], 1999[2] and 2007[3], plus continuing studies by the author since that time. It is closely based on his presentation at Euronoise 2009, Edinburgh.

Acknowledgements

Some of the work referenced in this article was conducted as part of the GKN Westland contribution to the HELISHAPE research project funded by the EC under the BRITE/EURAM aeronautics programme. The views expressed in this article are, however, those of the authors and do not necessarily reflect those of any of the AgustaWestland companies.

Startle effect will be much greater for helicopters flying at low altitudes

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Extending the bounds of wind energy

John Krouse. Using LMS Test.Lab

Engineers at the US Department of Energy's National Renewable Energy Laboratory use LMS Test.Lab in performing modal testing on next-generation wind power systems destined radically to change America's energy policies in decades to come.

As an inexhaustible, clean and economical way to generate electricity, wind power often tops the list of alterative energy sources for companies around the world facing volatility in fossil fuel prices, supply uncertainties and environmental issues. The United States in particular is rethinking its energy mix with an emphasis on environmentally friendly, renewable domestic energy sources. The *20% Wind Energy by 2030* study published by the US Department of Energy (DOE) in 2008 stated that generating 20% of the country's electricity from wind power is feasible by the year 2030.

To reach this ambitious goal, efforts are being stepped up to boost US wind capacity to 300GW, a more than ten-fold increase from present levels. In 2008 alone, the United States added more than 8GW of new installations, bringing the nation's total wind energy capacity to more than 25GW – the largest in the world, according to the American Wind Energy Association.

Generating this much power will take more than building bigger wind turbines, however. According to DOE, reliability and operability of turbines must improve. Also, with the number of easily accessible high-wind speed sites dwindling, turbines that operate efficiently in low-speed sites must be developed. All this will require advances in the design, simulation and testing of these next-generation machines - including variable-speed drive trains and advanced controls for adjusting blade pitch to match wind conditions.

Tools for advanced R&D testing

Work in addressing these requirements is spearheaded in the US by the National Renewable Energy Laboratory (NREL) – DOE's primary research and development center for wind power. A key element of efforts at NREL's National Wind Technology Center (NWTC) in Golden, Colorado, is aimed at testing proposed new concepts, as well as improving existing designs, often in connection with industry partners including wind turbine manufacturers and component suppliers.

In particular, modal testing is performed to identify resonant frequencies of the wind machine. As a nationally certified test facility, the NWTC also performs modal analysis as part of a suite of dynamic vibration tests for certifying wind turbine designs. NREL recently installed a LMS Test.Lab data acquisition and analysis system for performing these modal and vibration tests, and LMS Virtual.Lab software for correlating and updating simulation models. Measurements are made using a 96-channel LMS SCADAS mobile system in a lightweight, battery-powered laptop-size unit that is easy to carry up into a wind turbine nacelle, and between the NWTC and wind turbine sites in the field. The portable units are less than a third the size and weight of the NWTC's former cumbersome UNIX-based system.

Full modal survey

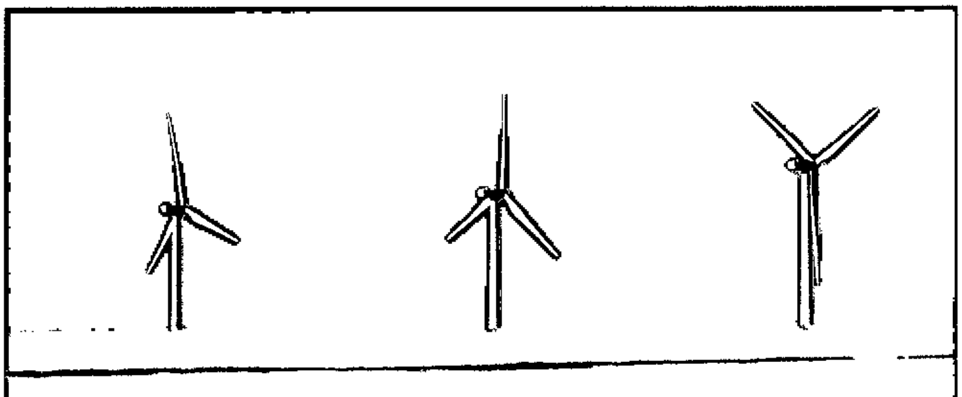
NWTC engineers have already used the LMS system to perform a full system model survey of a specially modified three-bladed 600kW wind turbine system known as the CART-3, which is used for advanced controls research. With its rotor fixed in a parked position, accelerometers were placed on the entire structure, including points on the tower, rotor blades, gearbox, and nacelle. Blades were excited to vibrate with impacts from an instrumented hammer. For other parts of the structure, hydraulic shakers were controlled by signals from the LMS SCADAS system which measured the amplitude response of the structure for various input frequencies.

According to NWTC Test Engineer Richard Osgood, one of the major advantages of using the LMS SCADAS mobile was that it could be used as a distributed data acquisition system, with slave units on the rotor, blades, nacelle, tower, and even a remote meteorological tower to measure wind speeds – all daisy-chained together and connected by fibre-optic cables to a master unit on a vehicle at the base of the tower.

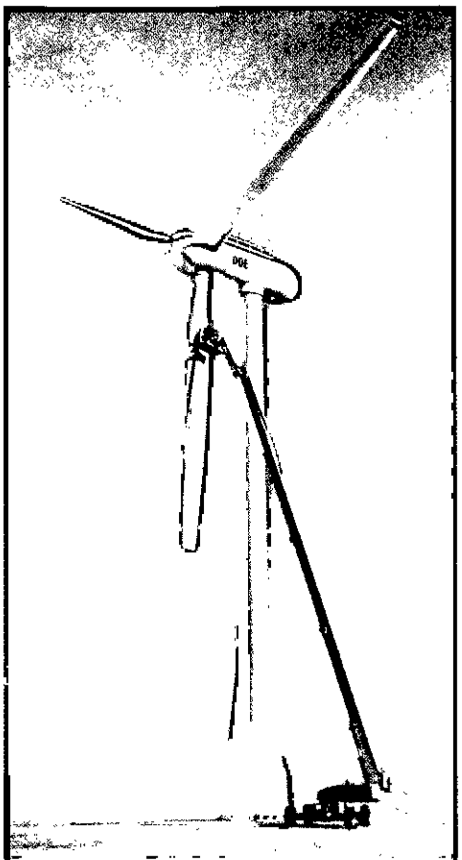
Replacing the previous UNIX-based system with the portable, scalable and distributable LMS SCADAS mobile system connected with fibre-optics saved tens of thousands of dollars for each test set-up, compared with cumbersome, more-expensive long signal cables that took much longer to set up, according to Osgood. This level of cost and efficiency was important in operations such as theirs in which budgets are extremely tight. Also, signal loss and background electronic interference had been significantly reduced with a distributed system based on fibre-optics, so less time was required in correcting for these discrepancies, especially in testing variable-speed drive trains that tended to generate considerable radio-frequency noise.

Using multiple-input / multiple-output acquisition and analysis capabilities for measured signals, the LMS system created plots – including animated mode-shape displays and frequency response functions (FRFs) – identifying ten fundamental system modes of vibration of the structure, including rotor bending and twisting, blade torsion, and tower fore-aft and side-to-side bending. The LMS system also accurately identified vibration modes often difficult to predict solely through simulation, such as coupled motion between the nacelle, tower, and rotor bending.

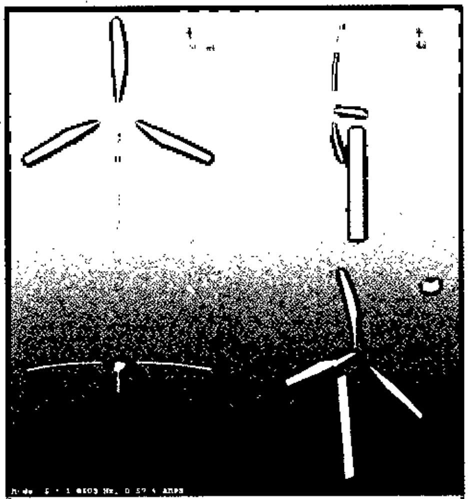
Test engineers used LMS Virtual.Lab software to correlate field test measurements with predicted results from a dynamic simulation model developed by NREL wind researchers. Initial evaluations were performed using a modal assurance criteria (MAC) matrix diagram showing where the experimental and theoretical types of modal data aligned and where they diverged. From this comparison, the test engineers were able to provide the dynamicist with information confirming simulation predictions and updating simulation modes when discrepancies were found. In addition, experimental identification of the turbine's drive train frequencies were used to adjust the wind turbine controller and resolve vibration problems occurring during operation of the variable speed power electronics.



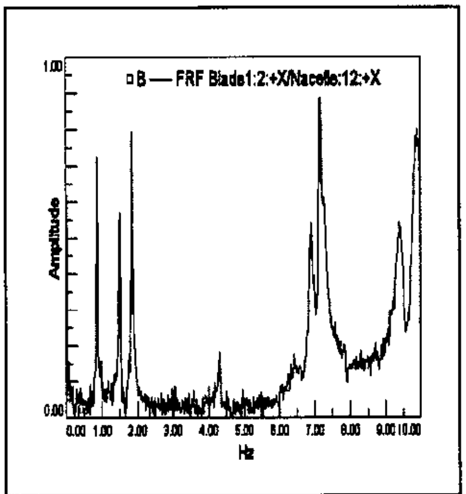
For a modal survey, an engineer positions accelerometers on the blade of a 600kW wind turbine with a 40-metre rotor diameter



The 96-channel LMS SCADAS mobile system is a lightweight, battery-powered laptop-size unit less than one-third the size of NREL's former UNIX-based system.



Animated mode shape displays show engineers how various parts of the wind turbine structure bend, twist and otherwise deform at resonant frequencies.



Resonant modes show up as peaks on frequency response function (FRFs) plots.

Adjusting simulation models

For obtaining accurate predictions of turbine vibration characteristics, test-based modal analysis was critical to adjusting models for a wide range of simulation including finite element analysis, multi-body dynamics, aerodynamics, acoustics, and blade pitch control, according to Osgood. Stiffness attributes and damping characteristics computed by LMS Test.Lab from modal data were essential structural parameters needed as inputs to the simulation model to represent structural members accurately as flexible, rather than entirely rigid, bodies. In this manner, simulations could more accurately predict the realistic bending and twisting motion of components that sometimes could lead to unacceptable deformations and instabilities.

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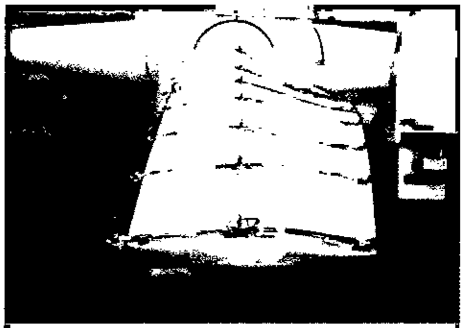
Extending the bounds ... - *continued from page 45*

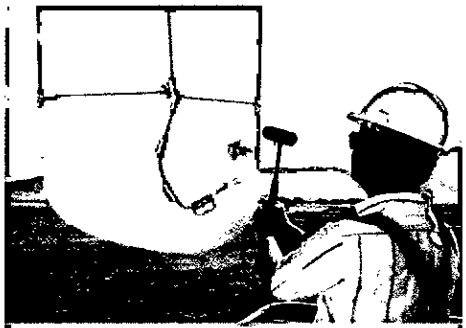
Value of an integrated system

Osgood noted that having this wide range of capabilities in a single system was an important criterion in their selection process, with LMS Test.Lab providing a fully integrated suite of tools (test set-up, control, measurement, signal conditioning, result analysis, data management, and report generation) all in the portable test unit. The PolyMAX feature, for example, automatically highlights resonances so that engineers can visually identify natural frequencies in minutes instead of spending hours looking through raw data. With an Active Pictures capability, live test data in the form of interactive, animated plots could be cut-and-pasted into Microsoft Office tools like Word and PowerPoint.

Integration of these functions, plus a fast processing speed, enables NWTC engineers to see results immediately after measurements are taken instead of waiting hours or days for post-processing. This fast visualisation helps engineers verify the test on the spot, see immediately how the structure behaves, get a good insight into the root cause of vibration problems, and easily identify particular areas that need further investigation.



An array of sensors is positioned on turbine blade for simulation model validation study.



An engineer hits turbine blade with an instrumented hammer to excite the structure into vibration.

A fully integrated system ensured that all tools needed were compatible and worked together properly. If a problem arose, there was only one vendor to contact. The major value of LMS technology in the testing operations was the more efficient and cost-effective operation, providing high-quality data and greater insight into the vibration characteristics of next-generation wind turbines that will serve the USA's energy needs in the coming decades.

Pivotal role of LMS technology

Bruno Massa, LMS Test Division's vice-president said that the company was honoured to have a pivotal role in NREL's testing operations for advanced wind energy systems. Their selection for this critical work confirmed the trust organisations had in LMS test solutions and demonstrated the effectiveness of the technology in supporting mission-critical applications in a wide range of industries around the world.

All images courtesy of DOE/NREL

Comprehensive report issued into health effects of ultrasound

No evidence that diagnostic levels of ultrasound are hazardous

Ultrasound has been used worldwide for 50 years in diagnostic scanning and ultrasound therapy, and more recently for destruction of unwanted tissues. Industrial applications of ultrasound include emulsification, welding, cleaning and sonochemistry.

The independent Advisory Group on Non-ionising Radiation (AGNIR), which reports to the Health Protection Agency (HPA), has reviewed the latest scientific evidence on the health effects of ultrasound (frequencies above 20kHz) and infrasound (below 20Hz). AGNIR reports to the sub-committee of the board of the HPA that deals with radiation, chemical and environmental hazards.

The report finds that the available evidence does not suggest that diagnostic ultrasound affects mortality of babies during pregnancy or soon after birth. The evidence also does not suggest any effect on childhood cancer risk. There have, however, been some unconfirmed reports suggesting possible effects on the developing nervous system – for instance, on handedness of the child.

AGNIR concluded that there is no established evidence that diagnostic levels of ultrasound are hazardous. However, further research is needed to determine whether there are any long-term adverse health effects, especially following exposure of the unborn child.

Professor Anthony Swerdlow, AGNIR chairman, said that ultrasound had been widely used in medical practice for 50 years, and there was no established evidence of specific hazards from diagnostic exposures. However, in the light of the widespread use of ultrasound in medical practice, its increasing commercial use for 'souvenir' foetal imaging, and the unconfirmed indications of possible neurological effects on the foetus, there was a need for further research on whether there were any long term adverse effects of diagnostic ultrasound.

The AGNIR report also looks at the available evidence for the health effects of infrasound, which is produced by aircraft, trains and other machines, as well as thunderstorms, wind and waves. It concluded that there was no consistent evidence that infrasound at levels normally found in the environment had physiological or behavioural effects, but there is little evidence about whether there are any longer-term effects.

HPA Response to the AGNIR Report

In response to the AGNIR report, the Health Protection Agency (HPA) says that parents-to-be should not hesitate to continue taking advantage of ultrasound scans for diagnostic purposes. However they should consider the uncertainties when deciding whether to have ultrasound scans that do not have a defined diagnostic benefit and provide only keepsake images or real-time scans.

Justin McCracken, Chief Executive Officer of the HPA, agreed that this was another thorough and detailed report from the independent advisory group. Overall, there was a track record of safety with diagnostic use of ultrasound, so people should continue using ultrasound for medical purposes. However, there were some uncertainties that needed to be clarified through additional research.

AGNIR report: Health Effects of Exposure to Ultrasound and Infrasound http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1265028759717?p=1199451989432

The Health Protection Agency's full response to the AGNIR report can be viewed at http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1265028749590?p=1207897920036

For more information on ultrasound visit http://www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1265018091081

Improving educational performance with better acoustics

Rockfon systems in the teaching environment

In today's dynamic, fast-paced society, schools are taking on an increasingly central and demanding role. Changes in family patterns mean that often both parents work full-time and children are spending more and more time at school. Methods of learning are constantly evolving and schools are now being designed for a new generation. Educational methods and learning styles are no longer the only reasons for choosing one school over another, as the design, layout and image are equally important.

Although every school should look different, they also need to blend into the local environment. Modern designs focus more on circulation and thoughtful layout, while group-work activities and individual learning programmes are leading to larger size classrooms and multi-purpose spaces. Architects now take into consideration the ever-changing role of the school as part of society, leading to more all-inclusive design.

Speak to anyone involved in education, such as teachers, students, architects and contractors, and the same major challenges will come up. Building materials suffer rough treatment and extremes of wear, and the same rooms must adapt to many different activities such as music, lectures, individual study and group work, but noise is by far the largest problem.

In a recent ministerial statement from the Department for Children, Schools and Families (DCSF) it was announced that acoustical testing will be a contractual requirement for all projects in England under *Building Schools for the Future*. In addition, any Local Authorities who have already constructed schools with BSF funding will need to prove that the most recent school complies with acoustical standards before further funding is released. It is part of a package of measures to improve acoustics in schools and ensure that all children, particularly those with hearing difficulties, have access to a learning environment that enables them to reach their full potential.

With an increasing tendency to use hard surfaces such as glass, steel and concrete in new school constructions, sound is amplified and reflected, resulting in very noisy rooms. Flexible open classrooms and parallel learning in the same space also contribute to higher noise levels. Background noise from HVAC installations, activities in adjacent rooms, road traffic outside, etc provide further distractions that can affect students' hearing and concentration.

Reverberation affects how well speech is understood and typically occurs in rooms with hard reflective surfaces. If levels are high enough, students lose concentration, teachers have to speak more loudly and speech intelligibility diminishes. Young

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Improving educational... - *continued from page 47*

children are especially vulnerable to this, and the situation can be made worse in highly reverberant rooms.

The main determinants of reverberation are the geometry of the room and the amount and distribution of absorbent materials. Utilising acoustic ceiling tiles, wall absorbers and/or 'islands' will reduce reverberation and increase speech intelligibility. For example, in a standard classroom of between 180 and 250 m3, the installation of an absorptive ceiling with high sound absorption will decrease reverberation time to a sufficient level to create good speech intelligibility.

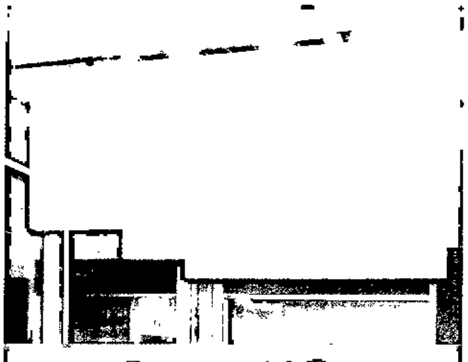
Andrew Morley of SCL Interiors recently worked alongside Rockfon to engineer specifications that would best suit the site criteria for the new-build Complex Needs School at Churchill Park in Kings Lynn, Norfolk. Rockfon's new Sonar dB40 was installed to the majority of the project, since the internal walls of the main teaching areas did not extend full height. A greater degree of soundproofing was required through the ceiling to limit room-to-room noise transfer. Sonar dB40 provided the ideal solution, according to SCL.

Rockfon has nearly 50 years of expertise in the education sector. Installing a Rockfon dB ceiling combining high sound absorption and high sound insulation contributes to a decrease of the ambient sound level in classrooms as well as insulating against intrusive noise from installations in the ceiling void and adjacent spaces.

Further reductions can be achieved with Rockfon Contour acoustic baffles and Rockfon Eclipse ceiling islands. Baffles are particularly useful where frequent and unhindered access to service installations is required, but also for providing additional sound absorbency to existing acoustic ceilings. For areas where a traditional suspended ceiling cannot be used, such as those with a glass roof or thermal mass buildings, Rockfon Eclipse ceiling islands are the answer. Absorbent on both faces, the islands allow air to flow freely around the room for thermal mass, while delivering the best in class sound absorption with Class A1 fire protection.

Rockfon offers a comprehensive range of acoustic solutions including ceiling tiles, baffles, wall absorbers and islands, all made from a 100% stone wool core. Rockfon products are known for their superior fire resistance and acoustics. Additional benefits include dimensional stability, even in up to 100% relative humidity, and a non-hygroscopic surface that has no nutritional value, therefore providing no sustenance to harmful microorganisms such as mould, fungi and bacteria. Rockfon ceiling tiles are also 100% recyclable, helping to reduce the burden on landfill sites and limit depletion of natural resources.

Installation of Sonar dB40 at the Churchill Park complex needs school



Contour acoustic baffles

Eclipse ceiling 'islands'

Wind turbine syndrome A Report on a Natural Experimant

Graham Parry and Rebecca Barnard.

This book has been awaited with great anticipation by those involved in wind farm developments and associated noise issues in particular, and they have been aware for some time that it was due for publication. Nina Pierpont states that she wrote the book (which she calls a report) because she saw a medical problem that few clinicians were paying attention to, or seemed to understand. She says that Dr Amanda Harry in the UK led the way in recognising the cluster of symptoms that people experience around wind turbines and subsequently she started encountering the problem in 2004.

The book is divided into four sections although interestingly, and possibly usefully she has devoted one section to 'The Report, for clinicians'; and another section to 'The Report all over again, in plain English for non-clinicians'. It must be assumed, especially in the light of comments she has made about some acousticians that only the plain English section should be of interest to acousticians!

You cannot criticise Nina Pierpont on the amount of detail she has put into her book about the new phenomenon of 'wind turbine syndrome', but there plenty of other matters of which to be critical. After an initial introduction and explanation about the reasons for her book she then proceeds to go through a lengthy set of symptoms that have been described to her by a number of families from different countries about the negative health effects resulting from wind turbines near their home. She then collates these symptoms to hypothesise about the core symptoms of 'wind turbine syndrome' (WTS), a syndrome which she has diagnosed and named herself. The core symptoms that the author has identified are: sleep disturbance, headache, tinnitus, other ear and hearing sensations, disturbances to balance to balance and equilibrium, nausea, anxiety, irritability, energy loss, motivation loss, disturbances to memory and concentration, and visceral vibratory vestibular disturbances (VVVD). These core symptoms are defined as common and were widely described by study participants, apparently closely linked in time and space to turbine exposure, and amenable to diagnosis by medical history. The author believes that the most distinctive feature of WTS is the group of symptoms which she has called VVVD. Apparently the adults who experience this describe a feeling of internal pulsation, quivering, or jitteriness, accompanied by nervousness, anxiety, fear, a compulsion to flee or check the environment for safety, nausea, chest tightness, and tachycardia (rapid heartbeat for those of us who are 'non-clinicians'). Part of the study noted that when the people removed themselves from the wind turbines many of the symptoms disappeared. The study that Nina Pierpont has carried out includes ten apparently affected families with 38 members aged between less than one year old up to 75 years old. The study was carried out entirely by telephone interview. The study did not however attempt to consider those people who are apparently unaffected by wind turbines in the vicinity of their homes.

The study considered the statistical association between VVVD and pre-existing medical conditions and variously found that depending on the specific factor there are highly significant associations or no association at all. The study appears to have carried out a detailed literature search, much of which is relied upon to show that where annoyance occurs for wind turbine noise then the symptoms which the author has described also occur.

It cannot be denied that some people living in the vicinity of wind turbines may experience some adverse effects from the noise and vibration produced by them. The major fault of this book and its conclusions is that it woefully lacks a comprehensive, robust, scientific or repeatable methodology. The author determined the symptoms of WTS by phone interview with families which she knew had been complaining about wind turbine noise. There was no evidence of any medical examinations or testing nor is there any evidence that she has linked these symptoms to any specific operations of the wind turbines other than that these people lived near a wind turbine.

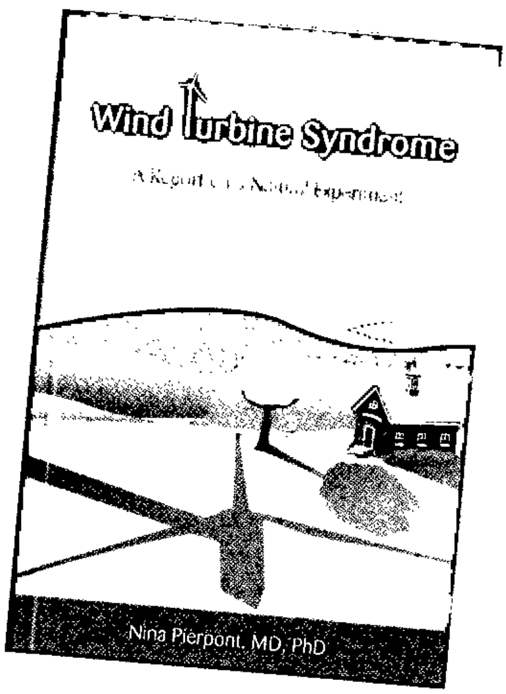
The author has quite appropriately identified the limitations to her study which include: only limited medical records were available; some participants had to be excluded from the study because they were unclear about what had happened and when; some participants may have minimised or exaggerated effects or issues; the study was limited to English-speaking participants; a very small case series which does not constitute an epidemiological study; and there was limited duration available to determine the resolution of the symptoms.

The author has supported the recommendations for noise level criteria of Kamperman G and James R. She goes on to suggest that the shortest setback distance for wind turbines from residences and sensitive receptors should be 2km.

In order to draw any positive outcomes from this book a major overhaul of the study methodology would be required. It would be necessary to combine robust acoustic measurements with medical examinations to determine any correlation between wind turbine noise and vibration and negative health effects for all residents near wind turbines and not just those who have complained. This would then determine if any new guidance in relation to wind turbines was required. Although this book has highlighted a potential problem with the noise and vibration from wind turbines it is a long way from being solid evidence for changing the current guidance in relation to wind turbines. In this respect this may well be what the author is legitimately seeking in that further study is required, and she has identified a number of suggestions for further research.

The book is only available for sale over the internet, from Dr Pierpont's web site.

Graham Parry MIOA
Rebecca Barnard AMIOA



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Committee meetings 2010

DAY	DATE	TIME	MEETING
Thursday	11 March	11.00	Council
Tuesday	6 April	11.00	Research Co-ordination
Tuesday	7 April	10.30	CCWPNA Examiners
Tuesday	7 April	1.30	CCWPNA Committee
Thursday	15 April	10.00	Meetings
Thursday	6 May	10.30	Membership
Thursday	20 May	11.00	Publications
Tuesday	26 May	10.30	CMOHAV Examiners
Tuesday	26 May	1.30	CMOHAV Committee
Thursday	3 June	11.00	Executive
Thursday	**17 June**	**11.00**	**Council**
Wednesday	16 June	10.30	CCENM Examiners
Wednesday	16 June	1.30	CCENM Committee
Thursday	24 June	10.30	Distance Learning Tutors WG
Thursday	24 June	1.30	Education
Thursday	1 July	10.30	Engineering Division
Tuesday	6 July	10.30	ASBA Examiners
Tuesday	6 July	1.30	ASBA Committee
Thursday	8 July	10.00	Meetings
Tuesday	3 August	10.30	Diploma Moderators Meeting
Thursday	2 September	10.30	Membership
Thursday	9 September	11.00	Executive
Thursday	16 September	11.00	Publications
Thursday	**23 September**	**11.00**	**Council**
Thursday	30 September	10.30	Diploma Tutors and Examiners
Thursday	30 September	1.30	Education
Thursday	7 October	11.00	Research Co-ordination
Thursday	14 October	10.30	Engineering Division
Thursday	4 November	10.30	Membership
Tuesday	9 November	10.30	ASBA Examiners
Tuesday	9 November	1.30	ASBA Committee
Thursday	11 November	10.00	Meetings
Thursday	18 November	11.00	Executive
Wednesday	24 November	10.30	CCENM Examiners
Wednesday	24 November	1.30	CCENM Committee
Thursday	25 November	11.00	Publications
Thursday	**2 December**	**11.00**	**Council**
Tuesday	7 December	10.30	CCWPNA Examiners
Tuesday	7 December	1.30	CCWPNA Committee

Refreshments will be served after or before all meetings. In order to facilitate the catering arrangements it would be appreciated if those members unable to attend meetings would send apologies at least 24 hours before the meeting.

Examination dates

CCENM - 14 May and 22 October
CCWPNA - 5 March and 5 November
CCHAV - 23 April
ABSA - to be confirmed
Diploma: - 10 and 11 June

Meetings Programme 2010

18 March
Measurement & Instrumentation group
Motor sport noise
Silverstone

7-9 April
Underwater Acoustics group
Sonar performance tools
Cambridge

22 April
Speech & Hearing group
Speech recording and analysis workshop
London

29-30 April
IOA/ABAV
Noise in the built environment
Ghent

26 May
London branch/Measurement & Instrumentation group
Aspects of noise & vibration measurements
London

3 June
Noise & Vibration Engineering group
Sound power measurement workshop
Buxton

14 July
Measurement & Instrumentation group
Construction noise and vibration
London

13-14 September
Underwater Acoustics group
Synthetic aperture sonar & radar
Italy

28 September
Noise & Vibration Engineering group
Transportation noise
Loughborough

2-3 November
Building Acoustics Group
Autumn Conference 2010
Birmingham

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