**Proceedings of the Institute of Acoustics**

# ACOUSTICS AND SUSTAINABILITY

P. A. Braithwaite Arup, Arup Campus, Solihull, Birmingham, UK
J. R. Cowell Consultant to Arup, Leavenheath, Colchester, UK

## 1 INTRODUCTION

Since the initial development of the concept of sustainability, and considerable uncertainty about its meaning and implications[1], there has been a need for extensive research and education to address the multiple factors contributing to sustainable design. This takes time. During the IOA Spring Conference of 2005, a paper was presented on 'Sustainable Design in Acoustics'[2] included the mapping of components of acoustic design against headline indicators in the sustainability assessment framework SPeAR®. This illustrated how substantial the connection between acoustics and sustainable design, both direct and indirect, may be. It also demonstrated that good design based on efficiency and high quality already incorporated much that we now consider to be sustainable. Because of the time needed to learn, it is natural that some impatience develops over taking actions that result in real improvements in sustainable design. While we may be on the journey, there is still the need for early improvement and, in particular, a wider appreciation of the consequences of our design decisions

This paper aims to highlight four areas for attention by acousticians, chosen to redress particular weaknesses perceived in current practice. Four specific actions are then recommended to accelerate the effectiveness of the learning programme.

## 2. ENGAGEMENT

There have been many maps, flowcharts and diagrams which aim to summarise the key components of sustainability covering a wide range of environmental, social and economic factors. The 2007 revision of SPeAR® as illustrated in Figure 1 remains one of the few which demonstrates the holistic nature of sustainable design in a simple to read diagram. The closer one of the 'segments' is to the centre of the diagram the greater strength that segment has in terms of sustainability.

This simplicity of presentation must be continued through all of the design considerations that we need to make to ensure that 'sustainable design' is founded in readily understood concepts and does not become a 'black box' of wizardry practised by a small band of experts.

A great deal of the practical response needed for sustainable design has not been researched adequately. After all, this is a very large subject which encompasses many concepts lying outside of the traditional building designers remit. Consequently, engagement with sustainability can be easily discouraged by the size of the challenge to understand enough to feel that results can be confidently regarded as beneficial. For this reason, it is usual for designers to choose areas with which they are familiar and are more easily understood, or to follow trends within the marketplaces. A particular current area of focus is 'green' building. This is where some real progress with ***indirect*** connection into sustainability is being achieved.

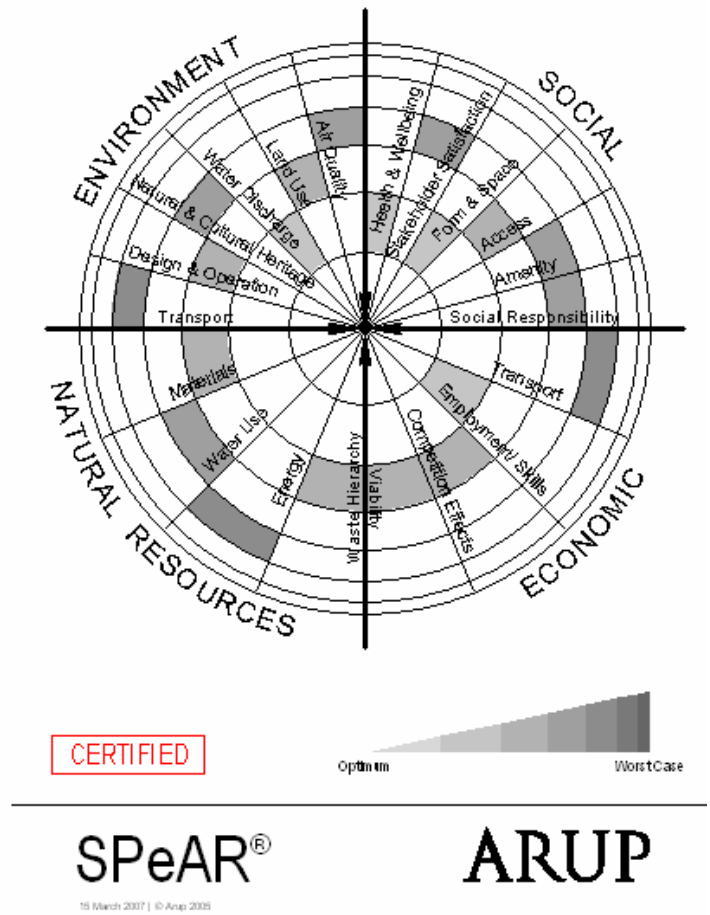


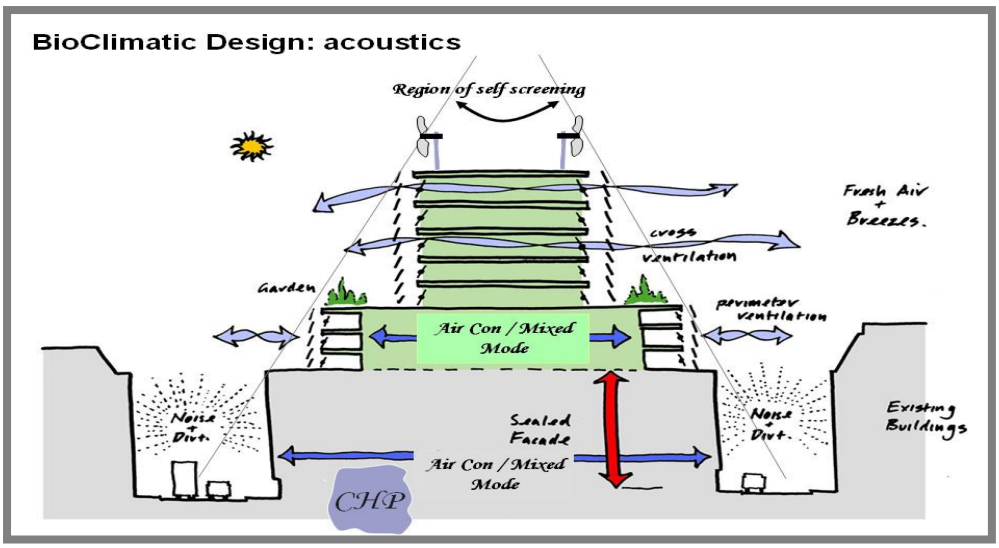

Figure 1 Headline indicators for successfully sustainable projects

In the field of acoustics, solid research and practice have begun to provide valuable reference material for acoustic design of 'green' buildings. We have seen an understandable focus on the effects of natural or assisted natural ventilation and thermal storage. Most effective building acoustic designers now have developed understanding of the key components – use of the stack effect, control over airflow pressure drop and use of thermal capacitance. Elements such as cooled ceilings, and reduced use of mechanical ventilation have tended to lower ambient noise levels, and so generate the need for higher internal sound insulation standards or raised background sound systems.

Arrangement of building geometry in relation to its surroundings offers major scope for developing more sustainable results. Figure 2 illustrates a number of common sense advantages of building arrangement, a number of which were applied in the Plantation Place development in the City of London, designed by Arup Associates.

The introduction of higher thermal insulation standards through Part L1A[3] and Part L2A[4] and increased investment in building facades has produced significantly more complex acoustic analysis of e.g. 'porous', twin skin facades, with airflow between the skins. Windows opening behind glazed screen facades can lead to reduced room to room sound insulation at the façade. New models are now being used to assess the behaviour in practice.

Choices between lightweight or heavy buildings need to balance the advantages of less material, easier carriage and assembly, and potentially lower costs against thermal mass and sound insulation. We should not be surprised if climate change brings more testing times for controlling noise from more wind and heavier rainfall.




Plantation Place, London EC3

Arup Associates

Figure 2 Building formation for acoustic advantage

In schools and hospitals, the design guidance, and regulation, aimed at more sustainable ventilation systems collides directly with the need to contain or exclude distracting noise. Budgets for resolving these conflicts by conventional means are often inadequate. This is an area where innovation is particularly important. We are now seeing, in school design in particular, new forms of projecting external screens and careful window configurations fighting to meet new regulations.

An additional acoustic challenge has emerged from the interest in integrating power generation into buildings, using wind turbines. Studies being carried out by Arup in Hong Kong aim to shape buildings to improve efficiency of wind flow into turbines for this purpose. This still leaves the challenge of reducing noise (both airborne and structure-borne) from the turbine, although the airflow patterns can be very much improved. We see a strong development in expertise amongst acousticians derived from wind farm experience becoming increasingly useful in this particular area.

This is merely commentary on what is being achieved. There are perhaps two priority actions needed to improve our performance:

I. We need more sharing of recent experience and reporting of findings in acoustic design of ‘green’ buildings, in publications and papers at events such as this.

II. We need to widen our sights to develop some of the connections between acoustics and the wider concept of sustainability. Simple consideration of the number of factors that determine sustainable design underlines the need to prioritise and optimise. A major area of weakness has been our lack of understanding of the impact of our specifications on resource efficiency. As with many other disciplines, many of the societal aspects of sustainability have received much less practical attention than the environmental and economic drivers. These two areas are addressed further below.

# 3. NATURAL RESOURCES

For many years, in the field of building acoustics design, we have had opportunities for promoting resource efficiency. Some examples of established fundamentals for good acoustic design include:

- Reduction of noise at source
- Planning separation of noise generating and noise-sensitive rooms
- Controlling background sound, so reducing sound insulation costs e.g. where aural privacy is needed.
- Use of re-cycled materials for acoustic performance
- Use of materials for both sound absorption and thermal insulation, albeit with vapour barriers to control condensation.

In describing these in the past, we have simply not used the term 'sustainable design' to describe the common sense value. On the other hand, perhaps many of us have not been sufficiently careful with our understanding of the full life cycle of the acoustic materials we are using, except perhaps in terms of safety, as required by CDM regulation. Often guidance on sustainability credentials of materials and material use is confusing. For example, in selecting a sintered aluminium absorbent panel, how do we view the sustainability of aluminium? The aluminium industry claims that re-use advantages are more significant than energy use in manufacture and re-manufacture. Do we make these judgements?

Do we consider the overall energy consequences of specifying fabric-faced fibreglass matt? In the earlier stages of thinking in sustainability of building products, considerable emphasis was placed on embodied energy. With time, the value of these assessments has seemed less significant compared with other considerations. Do we feel confident that we can determine the significance of such material properties? Another particularly awkward issue can be the procurement of acoustic materials from local sources, to reduce carbon emissions from transportation.

Perhaps the most dangerous of all is the migration of the vast majority of building materials suppliers to the adjective 'sustainable', regardless of material source, re-cycling/ re-use opportunities or environmental stewardship.

Very often, the research work has not been done to inform our decisions sufficiently. There is a case for more research and information-sharing relating to sustainability credentials in product selection. Fortunately, there are a few suppliers who are leading the way, one of these being Kingspan Insulation Ltd who was the first insulation manufacturer to obtain an Approved Environmental Profile, independently certified by BRE, for its major products. This data, based on Life Cycle Assessment methodology is being used by Kingspan Insulation as one of the benchmarking indicators for measuring improvements in its sustainability performance.[5] Indeed this supplier has gone one step further and has adopted sustainability as a mainstream business driver.[6]

While acoustic performance is obviously a major consideration in specifying materials, this should be considered within the wider concepts of sustainability. For example, if the most acoustically efficient material contains HCFCs with high ozone depletion potential (ODP) and a slightly less efficient material has zero ODP then, in terms of sustainable design, the latter material may be more sustainable. There will always be trade offs in sustainable design as many of the issues are in conflict, and sometimes the trade off may be with performance levels.

The following practical actions are proposed when assessing materials and specifications against good sustainable design standards.

- Check the material components to minimise non-toxic, zero ODP, low carbon characteristics
- Discuss the design philosophy with the design team, consideration of heavy versus lightweight structure, traditional construction or off-site will all have implications for the choice of components[7]
- Design for standardised elements to reduce waste[7]
- Check the sourcing of materials to minimise transport impacts. This can be extended to programming full-load delivery rather than part loads.
- Check long term in-use performance characteristics. As an example, some Photo Voltaic Cells may have a life of 15 years, but a major efficiency drop over the first three years.
- Check whether the supplier has carried out a Life Cycle Assessment (LCA) of its products, preferably independently verified. The LCA methodology provides a measure of the overall environmental impact of the product.
- Check the LCA of the complete building element, e.g. a complete wall. By using guidance such as 'The Green Guide to Specification[8] , a comparison of alternative elements can be readily made.
- Check that suppliers have achieved BS EN ISO 14001:1996 (Environmental management systems. Specification with guidance for use) certification, which requires continuous improvements in the environmental performance of the company, not just the product.
- Check whole life costs of the complete building or component rather than individual elements. A higher purchasing cost can easily be offset by lower maintenance or replacement over the life of the building.

Many clients or regulators are specifying particular levels of BREEAM or Ecohomes standards. Indeed the Government have recently introduced the Code for Sustainable Homes[9] , which builds upon the Ecohomes approach by using a star based rating system. If the above actions are taken, then the resulting design should be able to conform to the top levels of rating assessments without further design development. Reference to acoustic performance is limited to improved rating if sound insulation standards are bettered.

Research into the sustainability of materials is continuing with the development of Carbon Footprinting and Integrated Resource Management tools. While these assessment systems have not been widely adopted at the current time, they will become more widespread within the immediate future and will need to be considered as part of the specifiers' toolkit.

# 4. SOCIAL ISSUES

In the previous mapping of acoustics against sustainability, exciting connections occurring within the Social category have been slower to develop in building design than hoped for. Approaching building design from the viewpoint of people is not as common in architecture as one might hope. In our own field of acoustics, our criteria have often developed in defence of people against noise, vibration or excessive reverberation; less often based on preferred sound.

There is opportunity for real value from a review of established design criteria. Perhaps these were developed too defensively. We already see opportunity for background noise criteria in working environments to be modified when natural ventilation introduces a little more external noise. Within limits, we see trade off between the 'idealised' limits and the preference for being able to open up buildings more freely. With more emphasis on what we would prefer to hear (and in some cases, listen to), human benefit from our design objectives may well become more sustainable.

It is interesting to explore some of the components that appear to contribute to preferred sound (see Figure 3):

- Our safety and position
- Information
- Stimulation
- Protection from aural distraction – either by deliberate inattentiveness or masking
- Aural memory and conditioning
- Enjoyment of some sounds of nature
- Opportunity for tranquillity
- Sense of well being

Our defensive criteria do contribute to some benefits in these areas, but, perhaps we might achieve more by exploring these needs first, even if the development of the criteria seems more challenging. By introducing more humanity into our designs, we should be able to interpret the various design standards more effectively and sustain proper connection with the needs of humans and other life on the planet.

We also have the opportunity to take a more positive view of what we can achieve in spaces around buildings, in our courtyards, squares and underpasses. Figure 4 illustrates a recent example of the use of sound art and creative lighting design to make substantial improvement to the quality of 'dark arches' under the railway line in Leeds. The combination of absorptive cladding panels, provision of porous asphalt road surfacing and the installation of a sound system to support a permanent sound art composition reduce traffic noise and redirect pedestrian's perception of sound. Successful soundscaping and sound conscious urban acoustic design is now a serious objective for a number of major local authorities, including Greater London[10, 11]. Urban noise management and soundscape design are two components that will assist the next round of urban regeneration, aimed at bringing family housing back into cities.

# 5. EDUCATION

For the acoustician, it is clear that sustainability is reinforcement for good design. As with many specialist disciplines, our designs are most successful when we use well established principles of our subject, combined with the rich knowledge of many other disciplines. In the field of sustainability, there is a potentially daunting amount to learn about other disciplines. In the same way that we are learning about natural ventilation, we need to select and develop other areas of contextual knowledge to enable our sustainable design to have real value, rather than satisfy superficial 'green washing'. Collaboration between acousticians and specialists in sustainability, particularly on projects, now offers opportunity for accelerated learning. Education by doing is often the fastest way to learn.

Taking a much wider, longer term view of sustainability through acoustics, there is a case for reviewing patterns of education in aural perception. A good example of this is the often very limited education in the skill of listening well. In schools, it is commonplace for pupils to be instructed 'to keep quiet and listen' for instruction, or, 'listen to the music (or the birds)'. As instruction for future aural experience, this seems helpful, but very limited. Discussions held by acoustic designers, with clients, design team colleagues, and other stakeholders, are often handicapped by their limited understanding and experience of sound. There is real opportunity for improvement in patterns of education in hearing, listening and experiencing a wider range of sounds.

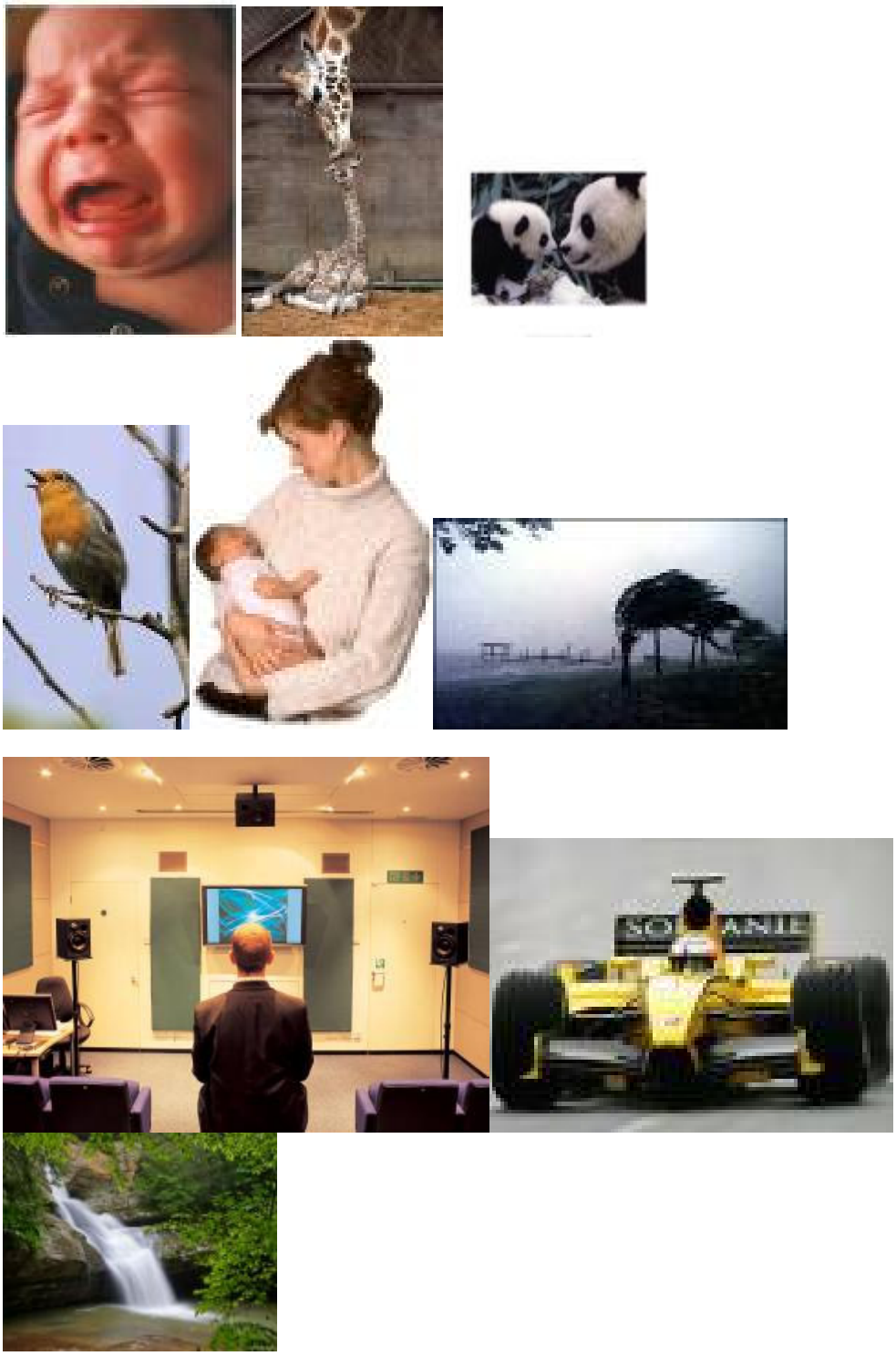


Figure 3 Security, position, sounds of nature, stimulation – preferred sounds?


Figure 4. Neville Street, Leeds – noise **reduction** and redirection of pedestrian perceptions using sonic art by Hans Peter Kuhn

Within the sustainability fraternity, the importance of 'active listening' is recognised. We can all hear, but often we are not listening. Giving full attention to the transmitter, whether that is a person, animal or other sound emitter, is often easier said than done. How many times have you been working on a project and when interrupted you go through the motions of listening but are still thinking about the design or pre-empt the talker by giving your views without really considering all of their points? We all do it. It leads to mis-understanding and often the breakdown in respect across disciplines, which is at the core of sustainable development.

As noted in the earlier mapping of acoustics against sustainability principles, **listening to each other may yet prove to be the vital need of society for its survival.** Education in real, effective aural communication is therefore an important and very ***direct*** component of sustainability.

We therefore suggest action for education in sustainability involves:

- in the short term, partnerships with sustainability specialists on current projects and self-awareness of the need to listen
- for the medium term, engagement with the next generations in earlier and wider appreciation of environmental sounds and listening.

# 6. CONCLUSIONS

Since an earlier mapping of the connections between the discipline of building acoustics and sustainability, developments in sustainable building design appear to have advanced in some areas as evidenced by experience of acoustic design of 'green' buildings. A wider connection with other disciplines is essential, as sustainability depends on the continued engagement with the learning and linking processes needed. Three particular areas have been identified for attention – better use of natural resources for 'acoustic' materials, social (people- centred issues), and short- and medium-term education a) to deepen our engagement with leading thinking in sustainability, and b) to strengthen the engagement of the next generations with the contribution that sound can make to a better, more sustainable world.

Four actions proposed are:

- Reinforcement of engagement with sustainability, through feedback of experience from 'green building' design, through publications, and events such as these.
- Reinforcement of methods and tools to clarify sustainability credentials of materials and combinations of materials commonly used in building acoustics design.

- A review of acoustic design criteria, to strengthen consideration of human preference as a foil to current 'defensive' criteria.
- Promote partnerships with sustainability specialists to accelerate our learning, and, for the medium term, strengthen a wider education in the aural environment in our schools.

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