THE FUTURE OF ACOUSTICS IN SPORTS VENUES

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1 INTRODUCTION

The relationship between acoustics and sustainability has become more evident over the past few years, especially with the introduction of Government initiatives to help deliver a better quality of life through sustainable development. It has taken a long time for the concept of sustainability to be fully embraced, starting with the Government's strategy documents in 1994 and 1999 (1) which have more recently been reviewed (2). This review has now led to an Action Plan (3) which sets out a framework for action with target deadlines for development with associated policies.

An example of sustainability with respect to sport, is demonstrated by the vision presented by the Olympic Delivery Authority (ODA) for the London 2012 Olympic Games and Paralympic Games. The concept of sustainable development has been clearly embraced by the ODA, with the publication of their Sustainable Development Strategy (8) which outlines the sustainability policy for the Olympics making this event the 'greenest games in modern times.'

At first sight, there does not appear to be a strong relationship between acoustics and sustainability. This paper however, gives the authors views as to the way acousticians should integrate acoustics to achieve the aims for a sustainable design and discusses practical examples in relation to sporting and music venues such as Wembley Stadium and the O2 Arena under construction in Greenwich at the Millennium Dome.

2 WHAT IS SUSTAINABILITY?

Sustainability has been defined in a number of ways but all definitions generally present the same common aims. The UK Sustainable Development Strategy (1) describes a common purpose for sustainable development which states *'The goal of sustainable development is to enable people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life of future generations'*.

Whilst all engineers and designers should influence the design towards a sustainable development, it is also vital that the client embraces the concept and drives the sustainable ethos to all disciplines. This will ensure that an action plan is developed throughout the project. The lead taken from the client will greatly encourage others to 'buy-in' to the importance of sustainable development.

In essence, the principles of sustainability for a development can be divided into two strands which are both closely linked (Figure 1). The design and construction phases of a project both should work in parallel to integrate the concept of sustainability throughout the project. This principle is directly relevant to acoustics such that the sustainable principles are adopted across all facets of acoustic design.

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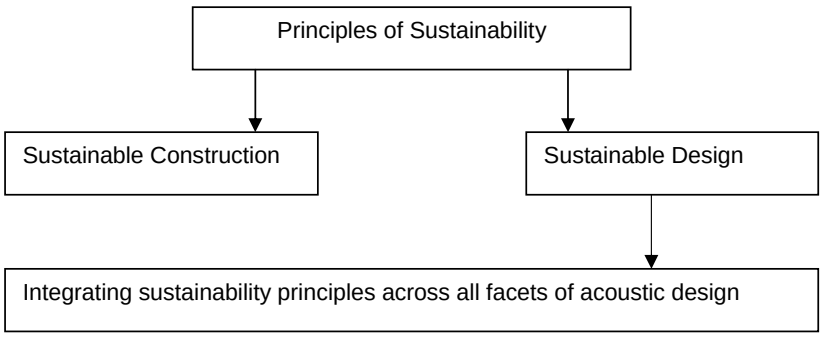
Figure 1



3 VENUE ACOUSTICS AND SUSTAINABLE DESIGN

One of the more difficult challenges is to develop practical steps to deliver sustainable designs based on a given strategy. For the acoustician this is no different, especially as no direct link is defined as compared to other disciplines such as resource and environmental systems for water, land and air which are expressly defined.

In terms of sound, noise and acoustics for sporting and music developments, the acoustician needs to look beyond the obvious issue of the use of recycled materials. This paper will discuss the following aspects which need to be considered as part of a sustainable design:-

Health and safety
Functionality
Environmental Responsibility
Sustainable materials

3.1 Health and Safety

It is paramount that designs meet the requirement of current and where possible future regulations in order to achieve a sustainable design. Often the requirement to meet higher levels of performance will drive the future direction of technologies. It is also important to consider potential changes in the regulations which may influence the design for the future. A good example is the regulations in respect of workplace noise exposure. The Noise at Work Regulations (4) were in force since 1990 and have recently been replaced by the Control of Noise at Work Regulations (5) which came into force in 2006 and typically reduces action levels by 5dB. When considering sporting and music venues, it should be noted, however, that the music and entertainment sectors do not have to comply with these new regulations until April 2008.

Hearing damage caused by exposure to noise at work is permanent and incurable and although research estimates that over 2 million people are exposed to noise levels at work that may be harmful, this condition can be entirely preventable. In terms of sporting and entertainment venues high noise levels are common by the nature of the event (crowd or concert noise).

Figure 2, shows the time-level history of a steward at a large football match (typical of a premiership game - capacity circ 36,000). As shown the daily personal noise exposure ($L_{EP,d}$) exceeds the lower and upper actions levels (5) by 14dB and 9dB respectively.

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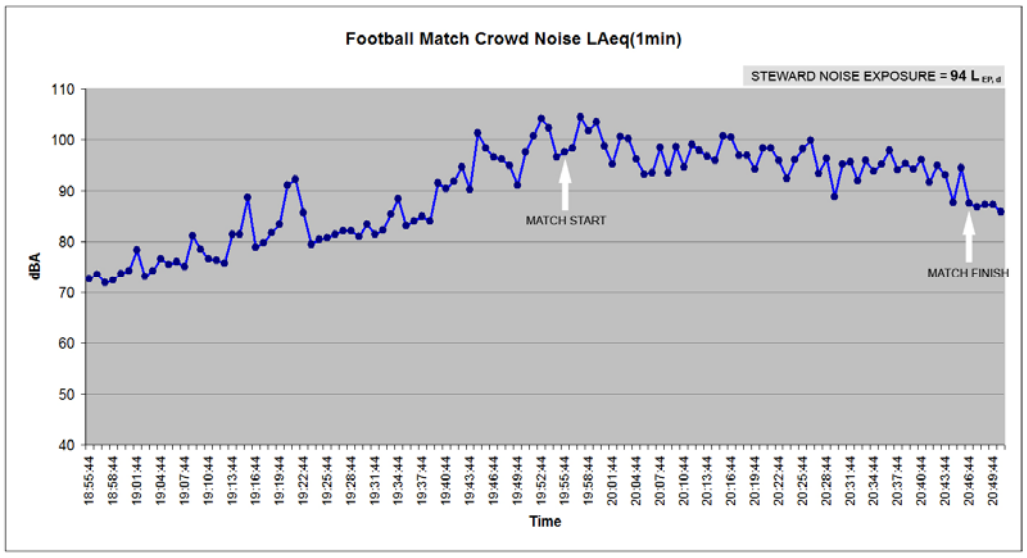
Figure 2 Football Match Time-Level history



In terms of sustainability, a number of issues should be considered at the design stage. These include:-

- Staff rotation (moving stewards to quieter areas) or employing more staff to work shorter periods will significantly reduce exposure. However, this impacts on staff accommodation and then there is a need to review space requirements at the design stage.
- Acoustic barriers and absorption built within the vomitory areas (position of the stewards) can be carefully designed to reduce employee exposure.
- Acoustic absorption within the venue to reduce the reverberant noise energy and hence overall noise in the venue.

In addition to the above, consideration should be given to meeting other parts of the regulations such as the demarcation of hearing protection zones, signage etc, which for many large venues would mean that the bowl should be identified as a hearing protection zone. Similar issues also need to be addressed in respect of venues which hold concerts, where audience levels can range from 95 to 105dB(A).

Other indirect effects of high noise exposure include employees having a higher risk of a workplace accident and other effects include headaches, tinnitus, high blood pressure and heart problems. These are examples of human efficiency being compromised.

Clearly the people attending sporting events are being exposed to high noise levels and there is a duty of care under the Health and Safety at Work Act (7) to safeguarding the health and safety of people visiting premises. Furthermore there is an issue regarding the comfort of people attending an event and this is discussed in the next section.

3.2 Functionality

For a sustainable arena design, the various spaces within the facility must be able to function under operational conditions for the space to be successful. A good acoustic environment is often essential to the functionality of most spaces, and this is particularly true in respect of entertainment venues.

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Peoples' expectations for a quality experience are also on the ascendancy and this experience is often assisted by the acoustics and sound systems within an arena or stadium.

The sustainable design of entertainment facilities need to cater for the current operational use as well as taking account of potential future operations. The designs should also ensure there is flexibility so that the design stays in line with changing technologies.

Some examples of designs that the author has actively been developing, with the aim to achieving optimal sound and acoustics, include the O2 Arena and Wembley National Stadium.

3.2.1 Wembley National Stadium

Given the high profile of this stadium a sustainable design was paramount to the success of the project. In respect of sound and building acoustics, a number of design features have been incorporated within the structure to enhance the experience for patrons whilst ensuring the building can function for the numerous operational uses. Designs include:-

- A sound system that can be used in tandem with the artists concert system to enhance the sound in remote areas of the stadium bowl as well as reducing environmental noise impact.
- A sound system that is highly controllable, such that it can page messages into very defined areas. This enables announcements to be targeted to the correct areas thus enabling the sound to be muted in other areas, reducing power requirements, increasing PA intelligibility, etc.
- The use of acoustic absorption in the roof to reduce the reverberant energy to assist with the intelligibility of announcements whilst balancing the need to provide a 'live' acoustic atmosphere for sporting events.
- The treatment of balcony fronts and risers with acoustic material, where practicable, to reduce long delayed reflections which can cause unwanted echoes during concert events.
- The angling of the highly reflective glazed windows of the Executive Boxes such that they are orientated 5 degrees left-right to each other thus breaking-up any unwanted reflections during concerts.
- The treatment of 'weak' acoustic links, such as the slot between the roof and the upper wall, required for ventilation, has been designed for sound to follow a convoluted path to reduce the environmental impact.
- Numerous acoustic treatments to function rooms, studios etc which have sensitive acoustic needs to ensure that they function without undue activity interference from within or outside the space.

3.2.2 O2 Arena

As for Wembley Stadium, a number of design features have been incorporated in the design to enhance the patron experience and assist in providing a functional facility. The O2 Arena is a self contained structure being built (completion due May 2007) within the Millennium Dome (now known as the O2). Other buildings (bars, restaurants, cinemas etc) are also being built within the O2 tented structure, just outside the arena. Figure 3 shows the proposed arrangement (courtesy of the architects HOK).

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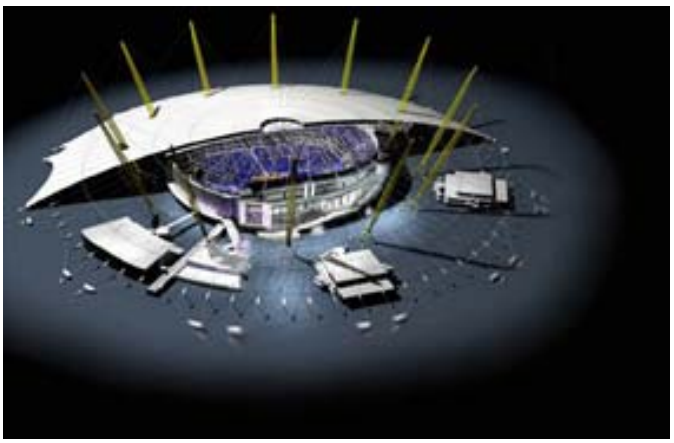
Figure 3 - O2 Arena layout within the O2 Dome, Greenwich



The primary use of the arena is for music events and therefore the priority has been to focus on an optimum environment suitable to this activity whilst not discounting other uses such as for sport etc. In other words, keeping the building design flexible and therefore sustainable in the long term. The main acoustic treatments include:-

- Acoustic treatment to the roof which incorporates sound insulation to reduce the transmission , in particular, the low frequency sound generated by concerts (roof density is circa 70kg/m2) and acoustic absorbing material to reduce the reverberant energy.
- Acoustic absorbing material to the balcony fronts, where practicable, to reduce unwanted reflections for patrons.
- Acoustic panelling to the rear wall and door of the Executive Suites to reduce reflections.
- Treatment to rear walls, exposed concrete cores and vomitory heads to minimise reflections.
- Low frequency bass chamber absorbers which are built into the bowl structure to reduce the build-up of low frequency sound.
- The design of a sound system which includes a separate delay sound system that can be used by touring artistes to enhance the sound quality in the upper areas.
- Designing an effective high performance envelope that minimises the noise impact to the environment and also to other buildings that exist within the O2 Dome structure, just outside the arena.

3.3 Environmental Responsibility

Clearly one of the key issues in relation to a sustainable design is the impact of the operation on the environment. Planning Policy, Regulations, Codes and local guidance need to be strictly followed, as these will strongly influence a development, however, we as designers need to look beyond these to truly meet the sustainability agenda. The setting of new standards and exceeding the minimum requirements instils the quality of the design for the future.

Consideration, in many cases, must be given to the legacy of the entertainment venue and indeed the environment that the facility must 'live' within for future years. For example both the O2 arena and Wembley National Stadium have residential developments planned within very close proximity to the venues and therefore careful consideration must be given to the design in respect of local land-use planning. The key drive for sustainable thinking is also to address the 'social needs' of others in conjunction with environmental responsibility.

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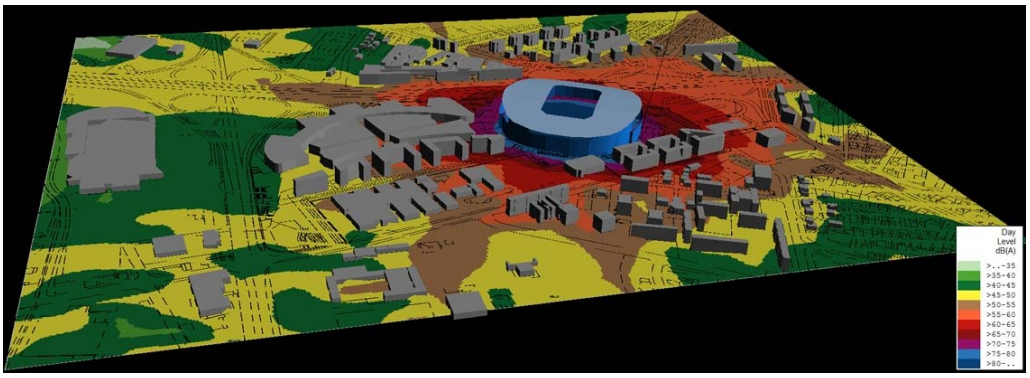
Acoustic designers need to understand the acoustic properties of their venue and produce noise maps with associated constraint documentation indicating the noise emission and potential impact on the environment. A typical example is shown in figure 4.

Figure 4 – Noise Map Predictions for a Stadium Concert



In terms of building longevity, facilities such as those being developed for the London Olympics must be designed knowing that after 2012, their use and size may change and therefore acoustic performance and technologies such as the sound systems need to be designed with this in mind ensuring flexibility for the future.

3.4 Sustainable Materials/Products

Due consideration should be given to sustainable acoustic materials especially when acoustic products can account for a large percentage of materials in a space, often most of the ceiling/roof and large proportions of walls and flooring. Whilst recycled products are one of the most common considered when discussing sustainability, research has now gone beyond this and we can now look at the 'whole life cycle' of materials to truly assess their sustainable credentials in line with the level of acoustic performance of the products under consideration. There is now much more general advice in the green procurement arena, with the BRE's Green Guide to Specification (7) and many other associated publications now available to all. These guides can be very useful when specifying an acoustic foam for example, some foams are actually blown using ozone depleting substances (HCFC's), which can easily be replaced within a more inert substance such as pentane producing the same acoustic results but reducing the impact considerably.

For stadia and arenas, consideration also needs to be given to communication systems. For example, the sound system can be specified such that it uses highly efficient and sensitive devices thus requiring less energy for a given output. The use of amplifiers and signal processing systems that lay dormant when not required thus again consuming less power. Whilst these design issues may seem relatively small, the effect is cumulative if all systems are designed along this sustainable route.

4 SUMMARY

This paper outlines the main issues related to sustainability in the context of acoustics and in particular stadia and arenas. Examples are given illustrating the acoustic issues that need to be considered for a sustainable design. Health and safety, functionality, environmental impact and sustainable products are all considered key issues that must be addressed by the acoustician for sustainable designs for developments now and in the future.

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