SOUND INSULATION AND VENTILATION IN SCHOOLS – A COORDINATED APPROACH

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1 INTRODUCTION

The purpose of this paper is to review requirements for Indoor Ambient Noise Levels (*IANLs*) from Building Bulletin 93 (*BB93*) for schools, specifically how they can be met with a range of external noise level conditions. The complicating factor is ventilation as this, along with glazing, will invariably determine the sound insulation properties of a building's external envelope. In the absence of its ventilation counterpart BB101, IANL requirements have been open to interpretation due to the term 'adequate ventilation' in BB93 not being formally interpreted. BB101 is due for release in late 2005, and sets definitive criteria for IANLs under varying ventilation rates.

It is always desirable, whenever practicable, to provide ventilation in schools by passive means. The challenge comes in passively ventilating buildings which are subject to significant levels of external noise, as there is a significant risk of compromising sound insulation against road traffic and other sources. This is a challenge for acoustic designers and, as both acoustic and ventilation requirements will form part of Building Regulations, is something that needs to be considered in a coordinated fashion.

2 BB93 REQUIREMENTS

2.1 Indoor Ambient Noise Levels

The IANL is defined in Section 1.1.1 for B93 as the $L_{Aeq,30mins}$ within critical school areas during the time when external noise is normally at its highest (during school hours). The IANL is to be made up principally by noise break-in attributable to external sources and noise generated by building services. Where ventilation is by passive means, the IANL will be dictated generally by noise ingress through ventilation openings.

2.2 Ventilation

For mechanical ventilation, the IANL will be when the systems are under maximum operational duty. This is likely to be when fans equipment is on high speed or full load.

For passive means, windows or ventilation must be assumed to be opened sufficiently to provide 'adequate' ventilation. The term 'adequate' is not defined in BB93, which has led to a fair degree of confusion between designers and enforcers. As with any such undefined wording found in regulatory documents, the meaning of the word can be interpreted and exploited by users of the document to suit their best interest. In November 2003 the DfES issued an explanatory note (see Teachernet website) that stated that 'adequate' could be taken to be the base ventilation rate, i.e. 3 ls^{-1} per person, until such time as Part F of Building Regulations was updated to give a firm definition. This would invariably result in noise levels within critical areas being significantly higher than stated IANLs when greater ventilation rates were required (e.g. during hot weather) and windows were opened. Whilst this makes design of ventilation simple and easily achievable, there are possible significant conflicts in many building contracts, where the designer/contractor is required to comply with all relevant British Standard. BS8233: 1999 states that for reasonable listening conditions in classrooms, noise levels should be no greater than 40 dB(A). It is therefore possible to comply with the explanatory note for BB93 but be in breach of contract by virtue of BS8233, during periods of purge ventilation.

Part F of Building Regulations is due to be released in late 2005, and in the same way that BB93 was embedded in Part E, the new schools ventilation document, BB101 will also be issued in late 2005 and will form part of the Approved Document.

3 BB101 REQUIREMENTS

BB101 is currently in its draft stages, but the acoustic requirements are unlikely to be changed when the document is finalized. BB101 is clearly intentioned to make passive means the key method of ventilating schools. This will be in line with Part L of Building Regulations and the increased awareness of energy usage and sustainability.

In addition to the base ventilation rate of 3 ls^{-1} per person, classrooms should be capable of being ventilated at a rate of 8 ls^{-1} per person as a purge rate when the room is under full occupation. In recognition of the difficulties surrounding achieving the IANLs with passive ventilation, BB101 will permit these to be raised by 5 dB(A) during purge ventilation, i.e. up to 40 dB(A) within classrooms, which is in line with the upper limit defined in BS8233: 1999. For mechanical ventilation, there is no permissible increase under purge ventilation rates and IANLs should be achieved under maximum design duty.

With BB101 in place, forming part of the updated Part F of Building Regulations, the DfES explanatory note on ventilation and BB93 will no longer be appropriate.

Designers are therefore faced with even more stringent ventilation requirements than at present, with a clear drive to provide passive solutions. To assist in the acoustic design, the 5 dB(A) grace will be afforded to reduce the risk of passive solutions being shelved due to impossible noise level targets.

4 NOISE LEVELS IN CONTEXT

It is important to appreciate when passive solutions can be achieved, and when external conditions will all but force mechanical ventilation to be installed.

4.1 Opening windows to provide ventilation

In the most basic of ventilation schemes, opening windows are the primary source of fresh air. It is commonly recognised that an open window can provide anywhere between 8 and 14 dB(A) attenuation against external sources, depending on its size and extent of opening. In order to provide an IANL within a classroom of 35 dB(A), therefore, the external noise level can be no greater than 49 dB(A). Under BB101 this could rise to 54 dB(A).

Research funded by the DfES shows that 90% of rural residential and suburban school sites have external noise levels ($L_{Aeq,30mins}$) in excess of 49 dB(A), where the façade is within 30 m of a main road. 98% of urban residential sites exceed this noise level.

Even with the proposed 5 dB(A) grace, it can be seen that practically all schools will have at least one façade where it will not be possible to rely on opening windows for the sole source of ventilation. In reality, schools are usually located in built-up residential areas adjacent to busy roads and even airports. It is no surprise, then, that most sites have been found to be in excess of Noise Exposure Category A as set out in PPG24: 1994.

Even when school buildings are set sufficiently back from noise roads or shielded by other buildings and structures, there is the risk of noise ingress from school activities such as PE being held on playgrounds, even the dreaded ride-on lawnmower! Such activities could reasonably be classed as everyday circumstances and, as such, should be designed against. The strategic arrangement of school buildings and areas is therefore critical if a simple passive ventilation solution is to be successfully implemented.

4.2 Attenuated forms of passive ventilation

The next step up from opening windows is to provide attenuated openings against external sources. This is a challenge to product manufacturers as, historically, this has only been possible on a small scale for residential requirements.

This gap in the product market prompted a number of bespoke ventilator designs, examples of which can be found in BB93. Generally, low level ventilation openings in the external wall, coupled with high level extract openings to promote a passive stack effect is found to be a workable option. The limiting factors are size of ventilation opening (too big and attenuation is minimized, too small and air flow is impeded in addition to pressure drops being too high) and physical siting and practicalities (ease of operation and maintenance, durability and susceptibility to abuse).

The use of complex passive systems makes design much more complex. Not only is acoustic calculation/modeling required, but often thermal simulations showing stack effects and ventilation flow are necessary to prove suitability prior to installation. Care should also be taken to ensure that no additional cross-talk problems are caused by through-wall ventilators to corridors or other teaching spaces.

Many manufacturers are adapting existing designs, and developing new products, to include discrete acoustically lined low-level inlets, combined sun pipes and windcatchers, quarter wave resonators and lined plenums to name but a few. The industry appears to be rising to the challenge posed by new regulation, which is promising.

Reduction of noise level at the building façades is also a practical method of attenuation. Providing noise barriers and bunding along site boundaries or arrangement of massive constructions nearest to noise sources can also be used to good effect, but are often shunned by architects and clients on the ground of security and aesthetics.

These engineering solutions can provide anywhere between 20 and 40 dB(A) attenuation against external noise, making them effective for external noise levels up to 70 dB(A), i.e. high Noise Exposure Category C (PPG24: 1994). This should cater for most school locations in busy urban areas.

4.3 Mechanical ventilation

Mechanical ventilation should be incorporated as a last resort, unless there are overriding reasons that leave no other option. As previously stated, excessive external noise (70 dB $L_{Aeq,30mins}$ and above) will invariably leave no option than to provide mechanical ventilation to achieve both background and purge ventilation rates.

The role of the acoustic designer in such instances is greatly simplified, as only plant and airflow noise has to be controlled. Traditional methods such as in-line attenuators (room-side, atmosphere-side and cross-talk), acoustically lined flexible ductwork and anti-vibration mounts are well understood and their attenuation characteristics well documented.

As an alternative to the traditional supply and extract ducted systems, new methods of providing mechanical ventilation, specifically with cooling, are being used. If energy must be expended in providing mechanical ventilation, then it is a designer's responsibility to investigate passive methods of cooling.

Ground source heat pumps (using geothermal energy for heating) and ground water cooling (using the constant ground temperature of 10 to 12°C as a regulator for variable temperature external air) are becoming more prevalent, especially as funding becomes available for non-PFI contracts. Other similar systems include ground-air heat exchangers that use the same moderating influence of ground temperature bring air through ground-borne pipes that can provide attenuation against noise due to distance and other losses.

There is a growing trend to use thermal mass and night cooling in schools. Whilst this is very advantageous in its low energy use, there are significant impacts on the acoustic design. The benefits are that glazing and the external fabric are usually very well insulated, which provides very good protection against external noise. However, due to the use of the structure for radiant cooling, there is a requirement for all hard finishes which makes achieving required T_{mf} values a challenge, especially in primary schools and rooms for use by the hearing impaired where values are very low ($\leqslant$ 0.6 seconds).

The use of emerging technologies and complex systems requires the acoustic designer to be aware of the fundamentals of operation and there limitations regarding methods of noise and reverberation control.

5 CONCLUSIONS

Increased regulation in school design has made meeting all the relevant criteria (acoustic, thermal, ventilation etc.) a potentially complex exercise.

The acoustic designer, like any other member of a design team, can not approach acoustic design from an isolated position, but must bear in mind other disciplines and requirements when preparing strategies for a Building Control submission. With increasing elements of school design being regulatory rather than design guidance, there is little room for derogation and deviation unless under extenuating circumstances.

A coordinated approach to acoustic and ventilation design must therefore be seen as a challenge which needs to be met. This will have a knock-on effect on the manufacturers of acoustic products, and prompt them to create systems which up until now have largely been bespoke in nature and costly.