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Constraints associated with PAN 56 and natural ventilation

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INTRODUCTION

This paper addresses the constraints imposed by the current Planning Advice Note 56 (PAN 56) with regards to achieving acceptable internal noise levels in inner city areas whilst utilising openable windows as the principal means of ventilation.

Although openable windows may be preferred by users and Local Authorities, alternative means of natural ventilation are available which provide both adequate ventilation and the required sound attenuation.

Consideration is given to alternative means of natural ventilation in terms of their adequacy in providing ventilation and their ability to mitigate noise from a road traffic noise spectrum. Ventilation and sound reduction data from field work undertaken by others has been used in some cases, subsequently, this assessment intends only to provide an indication of acoustic and ventilation performance, achievable with different ventilation strategies.

In addition a case study is presented where a unique passive ventilation system was designed by AECOM to allow the use of natural ventilation in a city centre location, subject to high traffic noise levels.

PLANNING AND NOISE PAN 56

This guidance document provides an overview of how noise issues could be addressed in development plans and planning applications. It also provides generic guidance with reference to noise mitigation measures.

The current PAN 56 is based on the principles of noise exposure categories and specific guidance relating noisy and noise sensitive developments. The noise exposure categories (categories A to D) allow potential residential sites to be rated in terms of their existing noise levels so that planners can interpret the likely impact of noise on the proposed development and identify the correct procedure in terms of granting planning permission on grounds of noise.

The noise mitigation measures described in the document mainly focus upon the arrangement of buildings with the aim of reducing the noise transmission from source to receiver either in terms of utilising distance or screening to provide attenuation. Little is discussed with regards to noise control measures at the receiver; however idealistic noise limits are discussed, as follows:

“*An adequate level of protection should normally be interpreted to mean commensurate with Category A levels. Where development is desirable in terms of the overall planning strategy for the area but where local circumstances or excessive costs prohibit the effective mitigation of noise commensurate with category A levels consideration may need to be given to relaxing noise standards. In such cases, internal noise levels within individual living apartments should be less than 45dB(A) during the day and 35dB(A)during the night. Levels should be predicted using appropriate time periods and the L_{Aeq} parameter*.”

In addition to this means of ventilation are loosely touched upon in the following statement:

“*In some cases, sound insulation measures may be appropriate e.g. of windows although it is reasonable for occupiers of noise sensitive premises to expect satisfactory internal noise levels with their windows sufficiently open for ventilation purposes. Only in exceptional circumstances should satisfactory noise levels be achievable only with windows shut and other means of ventilation provided.*”

The above clauses are generally considered to restrict development on sites that are situated in inner city areas where noise levels are generally high but may not be considered by the local authority to be “*exceptional”*.

NOISE LEVELS WITHIN INNER CITY AREAS

The following Figure 1 shows noise level predictions for Glasgow city centre produced during a Scottish Government noise mapping exercise.

Figure 1: Noise Levels in Glasgow City Centre

The predictions in Figure 1 give an indication of urban noise levels and it can be seen that in much of the city centre is coloured with yellow or red which indicates noise levels circa 55 and 60 dB (A) respectively. Areas near to the M8 are within the 75 to

80 dB(A) range, but it should be noted that circumstances where motorways run directly through a city centre are rare.

REQUIREMENTS FOR VENTILATION

The means of ventilation in a given space must not only provide adequate ventilation but also sufficient sound reduction to maintain appropriate noise levels within a given space. For passive ventilation an appropriate free area must be provided by the ventilation system to allow sufficient air flow.

The rate of ventilation is not only dependent upon the physical size of ventilation opening but also the internal and external environmental conditions. Pressure variation either side of the facade generated by wind or temperature differentials will dictate the extent of airflow via the ventilation aperture. Therefore in summer, on a hot still day when internal and external temperatures are comparable, the ventilation rate would be expected to be considerably lower than that on a windy day in winter.

With consideration to these factors, current standards and regulations stipulate a free area requirement to be achieved by trickle ventilation. This is the case for the Noise Insulation (Scotland) Regulations 1975 and The Scottish Building Regulations Part K

The Building Regulations Approved Document Part F (not enforceable in Scotland) stipulates a minimum effective free area requirement of 5000 mm^2, for trickle ventilation to a habitable room. In addition to this, the room must incorporate means to provide purge ventilation at a rate of 4 air changes per hour.

Although not mandatory in all parts of the UK, the Part F ventilation requirements are considered appropriate for comparative purposes when considering the different natural ventilation options.

FACADE SOUND REDUCTION

The sound insulation provided by a facade depends on the sound reduction indices of the elements which comprise the facade and their relative areas. In the case of a facade containing an element with a significantly lower sound reduction, such as a window, the window, or lowest performing element is likely to determine the overall sound insulation of the facade.

The composite sound reduction index of a partition which comprises elements with different sound reduction indices is derived using the following equation, which assumes random sound incidence.

$$\sum R = 10\,Log\,\frac{A_1 10^{\left(-\frac{R}{10}\right)} + A_2 10^{\left(-\frac{R}{10}\right)}}{(A_1 + A_2)} \qquad \textbf{EQ 1}$$

Where,

R = Sound Reduction Index
A_1 = Area of first element
A_2 = Area of second element

Although the above equation is used to determine the composite sound insulation of a partition it can be used to demonstrate the effect of incorporating an element within a facade with zero sound reduction, such as the free area provided by an open window. This composite sound reduction can be used to calculate the level difference provided by the facade.

The following equation is used to calculate internal noise levels resulting from an external noise sources. The equation assumes the surface area of the facade S, the reverberation time with the receive room T and the receive room volume V. The variable C is a correction factor which accounts for the angle incidence of the noise upon the facade.

$$L_{internal} = L_{traffic} - \sum R + 10 \log S + 10 \log T + 10 \log 0.16 V + C \qquad \textbf{EQ 2}$$

For the purposes of this example, the external noise level will comprise a traffic noise spectrum. This is an important consideration as the spectrum of noise will dictate the overall A-weighted level difference, as attenuation is not constant across the frequency range.

SOUND REDUCTION &VENTILATION PROVIDED BY A PARTIALLY OPEN WINDOW

Using the above equations, level differences were calculated for a partially open window, assuming the following parameters:

- The facade consisted 2 m^2 of double glazing opened 100 mm (4 mm pane / 12 mm airgap / 4 mm pane) and 5 m^2 of solid masonry construction

- The internal room volume is 30 m^3 and the mid frequency reverberation time is 0.5 s

- The noise spectrum was taken from free field measurements of road traffic noise in an inner city location

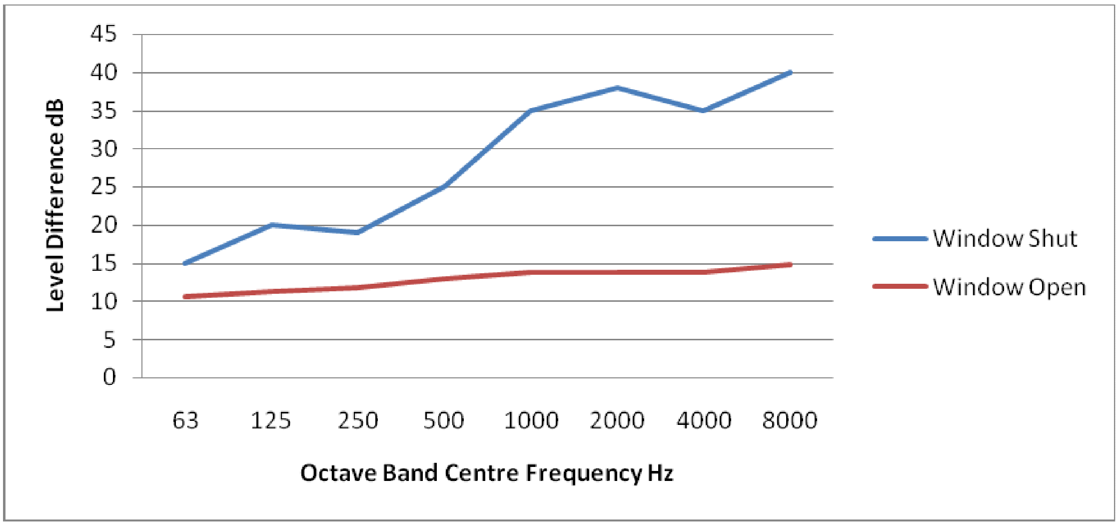

Figure 2: Level Differences Achieved from an open and closed window

The A-weighted level difference provided by the open window is calculated to be 14 dB which is consistent with the guidance contained within the current PPG 24 and previous work conducted by others. [2]

For comparative purposes the sound reduction provided by the facade was calculated with the window shut. It can be seen that by partially opening the window a significant reduction in performance results especially at mid to high frequency.

The ventilation rate achieved by an open window is proportional to the free area provided and subsequently its extent of opening. Field work undertaken by others [2] investigating the ventilation properties of an open window have established the following ventilation rates:

Window	Opening	Ventilation Rate m^3/s	Air changes per hour*	Wind Direction (degrees)	Wind Speed m/s
Single Glazed	100 mm	0.045	5.4	200	4
Single Glazed	100 mm	0.021	2.5	210	3

* Room volume = 30 m^3

Table 1: Ventilation Rate of an Opened Window

It can be seen that the environmental conditions have a significant influence on the rate of ventilation, however the above values can be used to establish approximate rates of ventilation for an open window arrangement.

SOUND REDUCTION AND VENTILATION PERFORMANCE OF A SECONDARY GLAZED WINDOW WITH A STAGGERED OPENING

The sound insulation provided by a conventional openable window is dependent upon its extent of opening and is generally low level as a result of large un-attenuated free areas provided by the window opening.

By using secondary glazing with staggered openings, significant improvements in attenuation can be achieved, more so when a form of absorptive reveal is located between the two panes. This arrangement provides a convoluted path for the sound to travel through, reducing the intensity at the second pane opening.

Work undertaken by at Salford University [1] established the sound reduction indices of secondary glazed windows with different sized staggered openings, and absorptive reveals. Using the sound reduction indices obtained during these tests, a calculation was undertaken using the same conditions as those identified for the open window scenario. The following level difference was established:

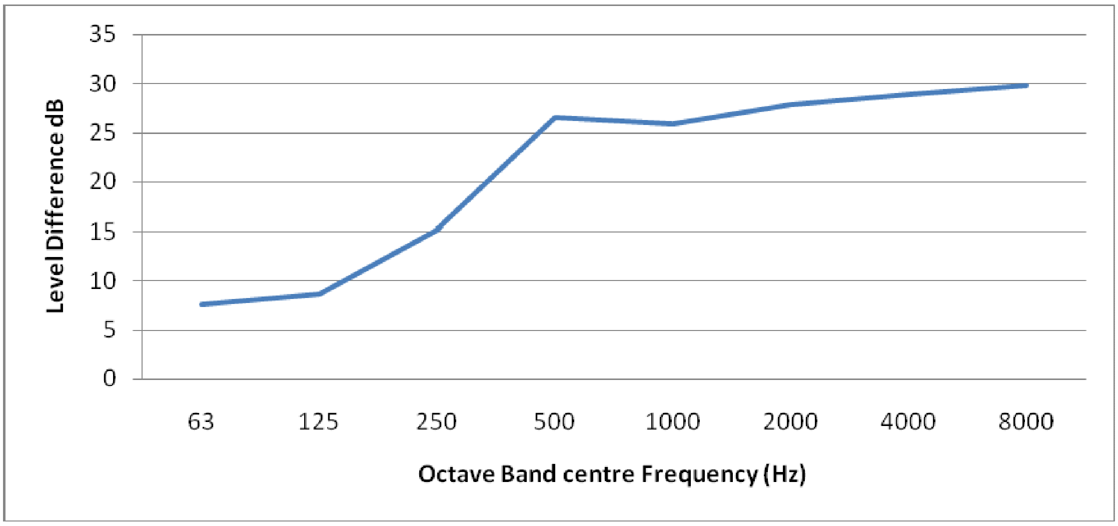

Figure 3 Level Difference Achieved with a Staggered Opening

It can be seen that significant improvements in mid to high frequencies could be expected when compared to a single pane open window scenario. The calculated A-weighted level difference is 26 dB.

Studies have been undertaken by others to identify the ventilation performances of this arrangement of glazing [2]. The findings of this exercise are as follows:

Window	Staggered Opening	Ventilation Rate m^3/s	Air changes per hour*	Wind Direction (degrees)	Wind Speed m/s
Secondary Glazing with absorbent reveals	100 mm	0.025	3	290	5

* Room volume = 30 m^3

Table 2: Ventilation Rate of a Staggered Opening in Secondary Glazing

It can be seen that the ventilation rate is similar to that achieved with a partially open single glazed window (see Table 1).

ATTENUATION PROVIDED BY TRICKLE VENTS

Trickle ventilators are small proprietary units mounted within the frame of a window. They are available in a range of sizes to provide different ventilation rates to suit the need of the space being ventilated. Their purpose is to provide background ventilation only and subsequently the free area provided by a trickle ventilator or multiple units is relatively low when compared to a typical window partially open.

Current standards and codes require a specific area of trickle ventilation to be provided by trickle ventilation when ventilating certain spaces. This area requirement is stipulated in terms of *free area or effective* or *equivalent area.*

The *free area* is derived by calculating the smallest cross sectional area, or sum of areas provided by the ventilator unit which allows air to pass through it. The drawback with this method of description is that is does not necessarily reflect the airflow which may be provided by the ventilator, as the passage of air may be restricted as a result of small apertures or a convoluted pathway.

The *effective* or *equivalent free* area provides information relating to the airflow rate of the ventilator. The airflow rate of the unit is measured and is described in terms of the free area of a single aperture in a thin plate which would provide the same airflow under the same pressure.

The acoustic performance of trickle ventilators is provided in terms of dB $D_{n,e}$ which is the normalised element level difference measured in a laboratory and is derived using the following equation.

$$D_{n,e} = L_1 - L_2 + 10 \, Log \frac{A_0}{A} \, dB \qquad \textbf{EQ 3}$$

Where,

L_1 = Level in the source room
L_2 = Level in the receive room
A_0 = Reference area of absorption (10 m^2)
A = Absorption within receive room

The level difference is normalised to a reference area of absorption (10 m^2), and $D_{n,e}$ values are derived in third octave bands. The resultant sound reduction can then be expressed terms of the single figure rating $D_{n,e,w}$ once it has been compared to the standard reference curves in accordance with BS EN ISO 717-1:1997.

Trickle ventilators are available with varying acoustic performances typically ranging from around 20 to 45 dB $D_{n,e,w}$. Assuming the same facade, room and external noise source as for the previous examples the reduction provided by a facade including trickle ventilation has been calculated. The ventilators used are an acoustic type achieving a sound reduction of 42 dB $D_{n,e,w}$ per unit.

The effective area provided by each ventilator is 3000 mm^2 therefore 2 units were included to make up the necessary area provided by Part F of the Building Regulations.

The resultant level difference can be seen in the following Figure 4.

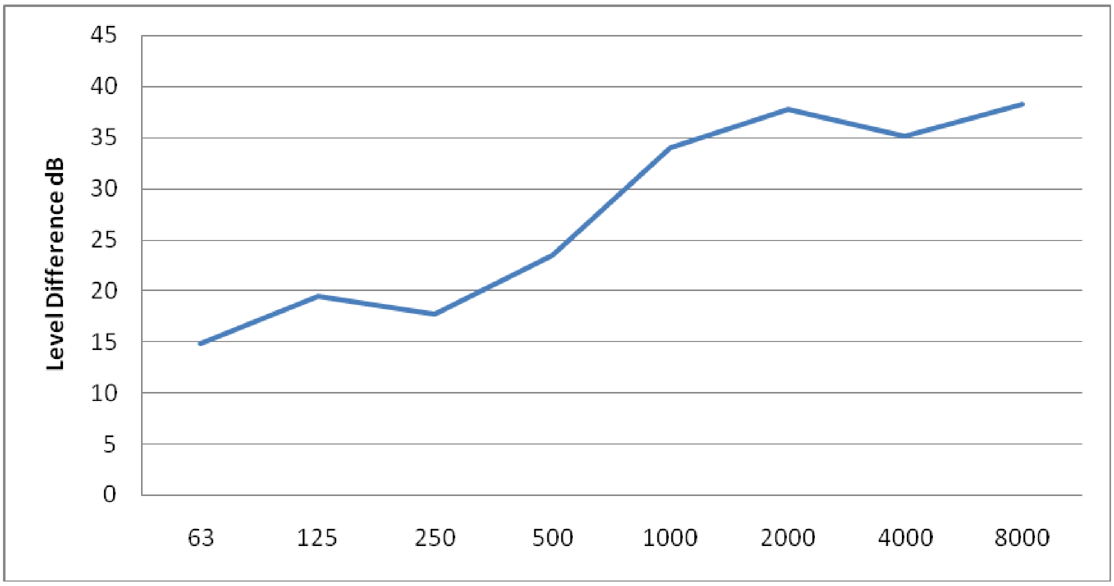

Figure 4 Level Difference Achieved With a Staggered Opening

Assuming the traffic noise spectrum, attenuation provided equates to 31 dB L_A. However this performance would only be provided whilst windows were shut. The windows would need to be opened to provide purge ventilation rates and in such case noise levels would be expected to rise by approximately 15 dB L_A.

CONCLUSION

The attenuation provided by various means of facade opening have been calculated based on manufacturers' data and studies undertaken by others. In addition, the approximate ventilation performance of these systems has been determined.

Calculations for each system assumed a traffic noise spectrum with an angle of incidence of zero upon a facade containing elements comprising glass and masonry and a free area. The room in which noise levels were derived is assumed to be a standard bedroom size with a mid frequency reverberation time of 0.5 seconds.

Calculations indicate that a facade containing a partially opened window will provide approximately 15 dB L_A reduction and a ventilation rate of 4 air changes per hour for the given room. This solution therefore may be adequate in rural, quiet locations but would provide insufficient attenuation in areas where the noise levels exceed 50 dB L_A during the night.

For secondary glazed windows incorporating staggered 100 mm openings suggest that a sound reduction of 26 dB L_A could be expected, whilst achieving a ventilation rate similar to that of a partially open single window. The increased attenuation provided by this arrangement would allow its use in areas with noise levels up to around 60 dB $L_{A\ (traffic\ noise)}$ whilst achieving the internal noise criterion of 35 dB L_A.

The facade scenario incorporating two trickle ventilators could be expected to provide a sound reduction of 31 dB L_A This scenario provides background ventilation only and in accordance with Part F, windows would be required to be opened periodically to provide purge ventilation.

The preference expressed within PAN 56 to maintain an open window philosophy for ventilation is likely to be due to a users preference to open windows whether it is technically required for ventilation or not. Realistically however there are many areas within urban environments which are subject to high daytime and night time noise levels which would exclude opening windows if the aspirational internal target noise levels are to be achieved.

If natural ventilation is key to the design of a building, alternative measures are available which provide not only the required sound reduction but achieve a suitable ventilation rate for a habitable room.

THE CASE STUDY BE PRESENTED AT THE CONFERENCE

REFERENCES

1. RD Ford & G Kerry *The sound insulation of partially open double glazing* July 1972
2. G Kerry & RD Ford *The field performance of partially open double glazing* May 1974