inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 3.8

LOW NOISE NATURAL VENTILATION SYSTEMS

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Keywords:
NATURAL, VENTILATION, INSULATION, SCREENING

ABSTRACT
Natural ventilation systems in buildings need to have inherently low airflow resistances so that the relatively small pressure differentials utilised to drive them can achieve adequate ventilation rates. Low airflow resistance can be achieved by opening large areas of the building façade but this will have the associated problem of significantly decreasing the noise insulation. The treatment of inlet and outlet openings using conventional noise control treatments will cause significant increases in the airflow resistances at the inlet of the building and therefore will often prove untenable. This paper describes the quantitative analysis of the variation of airflow characteristics with sound insulation of a treated façade.

1 - INTRODUCTION
The use of natural ventilation in buildings is generally considered to be desirable for reasons of both health and energy efficiency. However, the large apertures necessary to permit an adequate ingress of air with the small natural pressure differences available to induce air movement also present points of easy ingress for externally generated noise. Some traditional building features which allow natural ventilation have inherent noise attenuation properties e.g. courtyards, balconies. However, attenuation is generally limited in the low frequency region which in turn limits broad band attenuation to between 5 and 10 dBA for typical external sound sources such as road traffic.

Dissipative mechanisms such as acoustic louvres are popular in reducing exterior noise ingress while avoiding excessive screening or large air flow losses. The dominant air mass layer effect governing low frequency attenuation for louvres tends to increase as the depth of the louvre increases relative to the wavelength of the sound to be attenuated. However, to reduce airflow losses louvres are generally of limited depth and as such will tend to perform poorly in low frequency regions where wavelengths are long. This in turn limits the overall performance.

Larger ducts and pipes will have more scope for attenuation at low frequencies due to depth and/or end reflection and extended regions of dissipative treatments. However, extended lengths of duct can add large flow resistances to a system which may prove untenable for a natural ventilation system where available driving pressures may be minimal. Successful implementation of 'massive' splitter attenuators of extended length in the natural ventilation system at the Contact Theatre in Manchester, UK, give in the region of 12 dB at 63 Hz [1]. However, H-pot type chimneys rising 30 metres above the structure were required to generate sufficient pressure differentials to draw the required volume flow of air through the plenum into the main theatre auditorium.

A limited knowledge and research base is available to guide the acoustic design of components suitable for natural ventilation systems. Currently there are widely accessible design guides aimed at designers of natural ventilation systems giving guidance on airflow prediction. However, there is no evidence in the literature of research into simultaneous analysis and optimization of acoustic insulation and airflow resistance. This paper aims to show the potential value of such an approach and is presented as a basis for further research and development in the area.

2 - EXPERIMENTAL ANALYSIS

Parametric studies are underway at Liverpool University in the UK to assess and optimize the airflow and acoustic performance of simple natural ventilation components. As an example of the proposed approach, a simple raised screening device placed in front of an aperture has been tested using acoustic intensimetry to assess the static insertion loss of a screened aperture to normally incident sound compared to a free field source measurement. Boundary Element Method simulations of the plate were undertaken to give a two-way partial validation of each method and also with a view to further more complex modelling. Simultaneous airflow tests were carried out using a purpose built test rig consisting of a plenum chamber, fan and precision metering devices devised for the measurement of air flow and pressure differential across the test component.

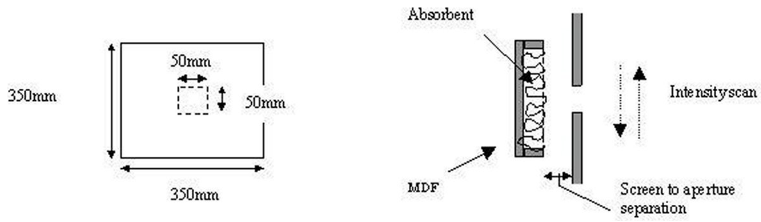

Figure 1: Simple screening device.

An absorbent backed plate with boxed in edges as depicted in Fig. 1 was initially tested. Acoustic insertion loss results in figure 2a show poor performance at lower frequencies (the scale model testing begins at 630 Hz as this represented the useful lower limit of the screened test facility in this instance) improving with increased frequency. The low to mid frequency performance of the device improves as the plate is moved closer to the aperture.
Airflow testing in Figure 2b shows that as the plate is brought closer to the aperture increased pressure drop is required to achieve a particular volume flow rate. From these results the flow coefficient relating air volume flow rate to the square of the pressure drop can be ascertained for the unscreened aperture and for the aperture with various degrees of screening.

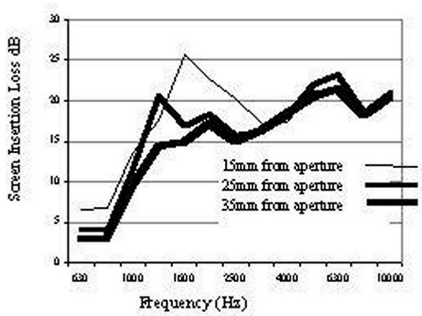

Figure 2(a): Acoustic insertion loss.

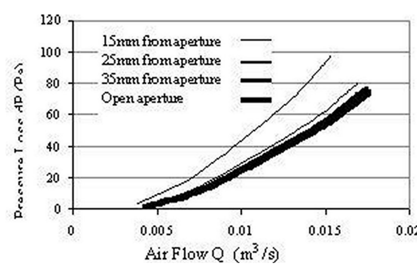

Figure 2(b): Pressure loss of screening device.

3 - ASSESSMENT OF ACOUSTIC AND AIRFLOW PERFORMANCE

As a simulated assessment of in-situ acoustic insulation and airflow performance one might look at the calculated SRI to road traffic noise of a standard wall of SRI road traffic of 40 dBA containing a natural ventilation component of varying proportional open area. Airflow through the modelled natural ventilation component can be assumed to be driven by half of a natural pressure differential which may typical exist between inlet and outlet of a building [3], working against predicted or measured flow coefficients giving a predicted volume flow rate into the ventilated space.
Results of this type of approach are shown in Fig. 3 for the screens tested in the previous section. The screens tested are scaled by factor 5 and the acoustic results transposed to the relevant 1/5 scaled frequency i.e. giving the attenuation results in the range 125 to 2000 Hz. The calculated composite attenuation of a wall of nominal $SRI_{\text{road traffic}}$ 40 dBA incorporating these natural ventilation component may now be calculated in conjunction with airflow passage calculated using scale models flow coefficients from section 2. Façade attenuation and airflow are also shown using manufacturers' data for a high

specification double louvre system. Fig. 3 shows that attenuation and airflow vary simultaneously with the proportional area of façade taken up by the natural ventilation component (aperture or louvre).

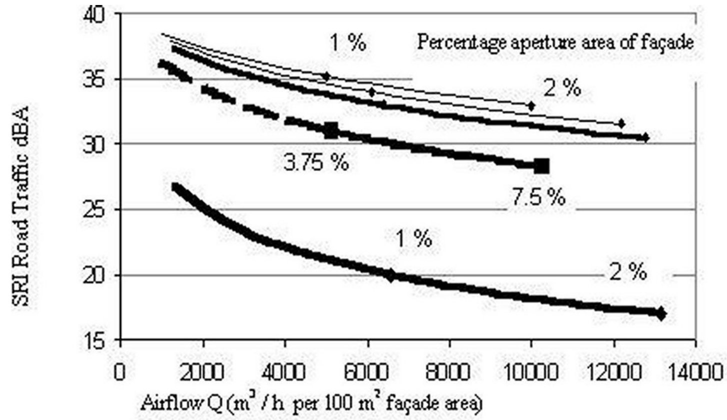

Figure 3: Predicted sound reduction index and airflow characteristics of a wall of nominal SRI road traffic 40 dBA containing apertures: a) simple screens, b) incorporating a double louvre and c) open.

In terms of design targets a typical large square plan room of one storey height a figure of 10000 m^3 / h per 100 m^2 of façade area may be expected to give in the region of 5 air changes per hour. This rate of airflow is often cited as adequate to achieve occupant sensible cooling. For this flow rate the composite wall and scaled screen systems are predicted to give 32-33 dB(A) attenuation to road traffic. The increased flow resistance of the closer set screens is marginally outweighed by the increase in attenuation despite more open area being required to achieve the flow rate. An increase of around 1.5 dBA for 10000 m^3 / h per 100 m^2 is shown as the scaled up screen is moved in to the wall. Predictions suggest that the screen arrangement is more effective than the standard acoustic louvre. The louvre attenuation is actually higher than the screen insertion loss but the lower screen airflow resistance requires less open area to achieve required airflow which increases insulation overall.

4 - CONCLUSIONS AND FURTHER WORK

The paper has introduced the simultaneous assessment of acoustic insulation of airflow characteristics with a view to design of low noise natural ventilation components. Scale model results are used in a parametric study of a simple raised screening device over an aperture in a wall. Increased insulation to normally incident sound is apparent as the screen is positioned closer to the aperture despite the increase in proportional area of aperture required to balance airflow losses. Results also suggest that the raised screen performance in terms of airflow and acoustic insulation may be superior to that predicted using manufacturers' data for a high specification double louvre. Further work is planned to include use of reactive systems and a duct based active noise control system to increase poor low frequency performance which conventionally limits attenuation of ventilation inlets.

REFERENCES

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2. **Liddament ML.**, *A guide to energy efficient ventilation*, AIVC, 1996