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NOISE IN OFFICES AND URBAN CANYONS

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1. INTRODUCTION

Since 1992 LEARN has been undertaking research related to the noise limitations to the use of natural ventilation in buildings in urban areas (1,2,3,4,5,6,7). Noise is often used as an argument against natural ventilation and therefore has a direct impact on global warming where air-conditioning is used as a result.

During the last three years LEARN was a partner in the EU (Joule Programme) funded SCATS project which sought to develop control algorithms for both natural ventilation and air-conditioning control systems based on the theory of adaptive thermal comfort (8). LEARN built the instrumentation (9) to undertake office surveys in 25 offices in five European countries, amounting to 850 people, on a monthly basis over the year. As part of the survey the noise was measured at each workstation and a question answered concerning the noise environment. The recently concluded project only analysed the thermal data but some early noise results are presented here.

Apart from noise, air pollution is the major factor cited as preventing natural ventilation. In urban areas this may concentrate at street level leaving the air at the upper storeys relatively pollution free. Similarly noise may be reduced at the upper storeys. LEARN is a partner in another EU project (FP5) URBVENT which commenced this year. LEARN is responsible within the project for investigating the variation of noise level with height in various configurations of the urban canyon, which is not a feature of commercially available road traffic noise prediction programs. The experiments will be conducted in Athens which is well known for its 'canyons'.

2. NOISE IN OFFICES: THE 'SCATS' PROGRAMME

A 'virtual instrument' (10) (fig 1) designed at the University of North London was used to obtain comfort data in monthly surveys. The response to the acoustic environment was measured on a 7 point scale as indicated in table1.

Table 1. Scale for assessing noise: replies to the question: "How do you find the background noise level at your work area at this time?"

Vote	Description
1	Very Noisy
2	Noisy
3	Slightly Noisy
4	Neither Noisy nor Quiet
5	Slightly Quiet
6	Quiet
7	Very Quiet

Immediately before the subjective survey was undertaken, the noise was measured over a 2 minute period close to the workstation, 1 second Leq 'A' and linear readings being measured simultaneously by a sound level meter developed for the project by 01dB (10). The difference between the linear and 'A' measurements was to be used to characterise the low frequency noise content. From this information, L_{90}s, L_{10}s and L_{eq}s were calculated for the 2 minute period. Because of an early bug in the programme, there was an error in calculating the 2 minute Leqs in the initial trials so that they are omitted from the following presentation. They might roughly be regarded as 2.5dB less than the L_{10}s. Results are presented here for offices in the UK, Sweden, France ('A' only), and Portugal.

The results of the survey are shown in figures 2-5. They indicate that the Portuguese were more tolerant of noise than the others, while the Swedish the least. A mixture of air-conditioned and naturally ventilated offices were used, primarily air-conditioned in Sweden. Their noise levels were very low so statistically there is little evidence to support their potential tolerance of higher levels. Some adaptation to higher noise levels is suggested however.

Taking the total population both the L_{A90} and L_{A10} results (figs 2 and 3) show a line of zero gradient at a vote of 4 (neither too quiet nor too noisy) until an L_{A90} of 52dB and an L_{A10} of 65dB (figs 4 and 5). For the linear measurement L_{A90} results showed an approximate straight line over the whole noise range, giving a value of 64dB at a vote of 4 while the L_{A10} showed zero gradient at vote 4 until 72dB. The differences would indicate both a higher low frequency content in the background level, and less tolerance of the low frequency content of the sound as the noise levels rise though more sophisticated statistical analysis would be necessary to confirm this. It is interested to note that the UK results are the most representative of the total results.

For comparison BS 8233:1999 indicates a good background level of L_{Aeq} = 40 dB and L_{Aeq} = 50dB for reasonable background levels in cellular offices (at the top end of the range for open plan offices). While the measurement of the background level is not identical (but what really constitutes background level?), maybe the increase in noise generated within the office has increased a tolerance of background level.

The results shown are a mixture of air-conditioned and naturally ventilated offices. In Sweden most of the offices were air-conditioned and in Portugal mostly naturally ventilated. In the other countries there was an even split. It has been argued sometimes that people in naturally ventilated offices will tolerate a higher level of background noise than those in air-conditioned offices. A poorer noise environment is sacrificed for greater individual control. The data has yet to be separated for processing.

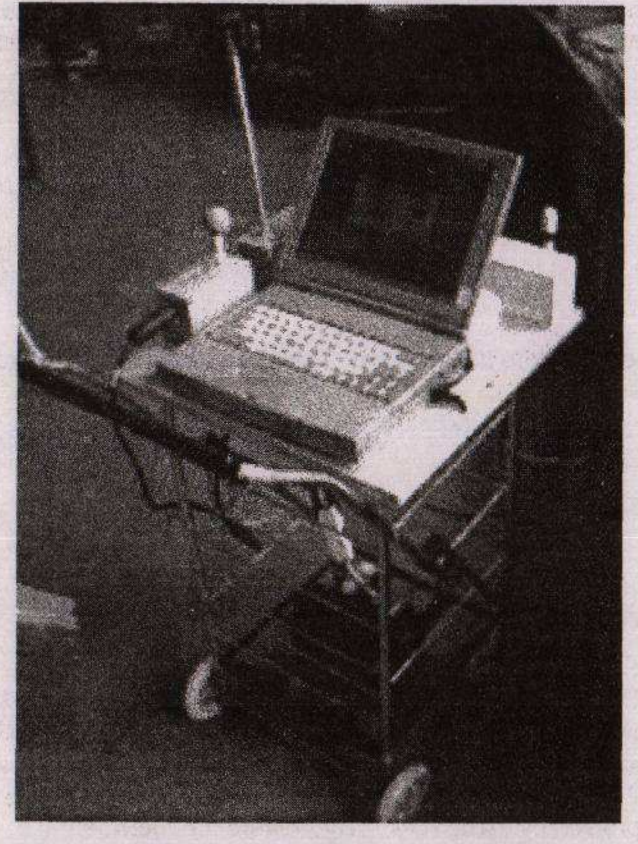

Figure 1. The SCATs instrument trolley. The sound level meter is not shown in this illustration but was attached by a flying lead and placed on the desk close to the subject during measurements.

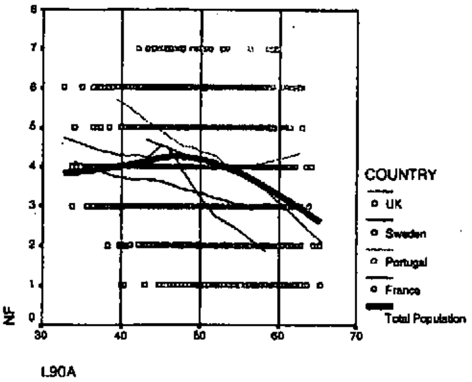

Figure 2

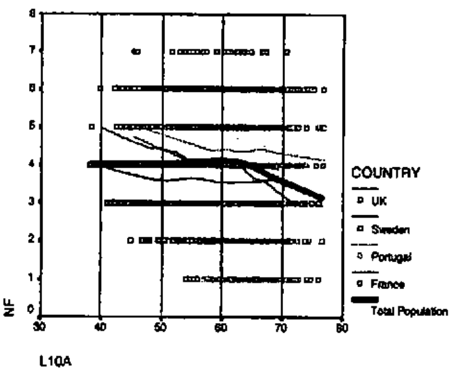

Figure 3

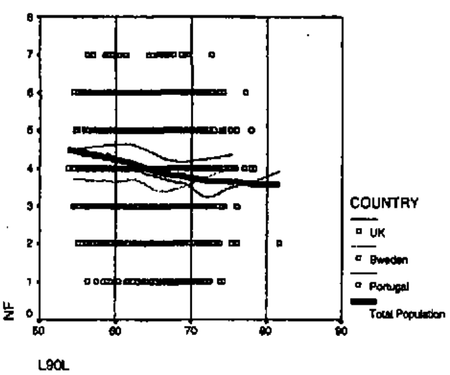

Figure 4

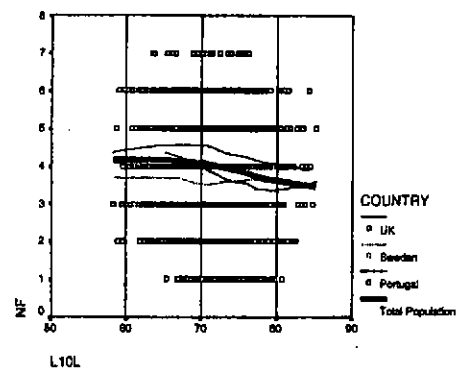

Figure 5

3. CANYON NOISE STUDIES

While some commercial road traffic noise programs are based on ray tracing (e.g. Mithras), and might be deemed suitable for prediction of noise in canyons, they do not have a facility for predicting change of noise with height. Kang (11) has developed a program for comparison of radiosity and image source techniques (essentially ray tracing) to compare specular and diffuse reflection techniques in canyons.

Whether a surface may be diffusing or specular depends on the nature of the surfaces (e.g. street furniture, vegetation and balconies) and the wavelength of the sound. Variations of noise with height and along side streets were examined. Typically a canyon 20m wide and 30m high showed an attenuation, with a point source at a height of 1m, of 7-8 dB between 1m and 30m heights at the boundary. Diffusing surfaces provided substantially more attenuation (10dB) 200m down a side street.

During this summer LEARN is undertaking a series of field studies in the street canyons of Athens. Athens is an ideal choice for such studies as it provides a variety of dimensions of street canyons both with and without balconies. There must be some doubt as to whether any road traffic noise program can predict the noise level even at ground floor boundaries in these canyons. While it was not the purpose of this work to evaluate any of the traditional programs, it would be an interesting study to see whether any gave predictions close to the measured levels. Clearly urban canyons are not solely confined to Athens. Many streets in central London have canyon like characteristics and both new build and refurbishments are often faced with whether natural ventilation can work and airconditioning can be avoided. The issues involved are pollution, air movement in the canyon and noise with their vertical distribution.

Noise and pollution are major disincentives to the use of windows for natural ventilation in an urban context. The objective of these measurements is to help designers to judge the viability of natural means in the provision of cooling ventilation in the context of an urban canyon. In particular whether the upper floors of the building may be naturally ventilated when this is inadvisable nearer to street level. It is hoped that once the study in Athens is completed we are able to perform a similar study in London

4. CONCLUSIONS

Across Europe considerable national variations in sensitivity to noise were encountered. Whilst it is possible that there is some confounding between nationality and building servicing, the differences are significant. The research reported suggests that current British Standards limits to background noise in offices may be over-cautious.

The effect of noise attenuation due to distance from the noise source needs to be considered when deciding on whether to use natural ventilation. This may be particularly so in urban canyons where the noise level on upper floors may differ by several decibels from that at street level where many noise measurements are taken.

Research being undertaken by the Low Energy Architecture Research Unit at the University of North London is aimed at evaluating and quantifying these effects.

5. REFERENCES

1. Wilson M. (1992) A Review of Acoustic Problems in Passive Solar Design. *Proc EuroNoise'92 pp901-908*
2. Wilson M, Nicol F, Singh R. (1993) Measurements of Background Noise Levels in Naturally Ventilated Buildings, Associated with Thermal Comfort Studies: Initial Results, *Proc IOA 15(8), pp 283-295*
3. Wilson M, Nicol F. (1994) A Comparison of Tolerated Noise Levels in Offices in the U.K. and Pakistan and Their Relation to Simultaneous Thermal Comfort Measurements, *Proc WREC, Reading pp 1006-1008*
4. Wilson M, Dubiel J, Nicol F. (1994) Simultaneous Acoustic and Thermal comfort in Differing Climatic Regions. *Proc European Conference on Energy Performance and Indoor Climate in Buildings, Lyon, pp398-403*
5. Wilson M, Dubiel J, Nicol F. (1995) Thermal and Acoustic Comfort, *Proc. Conf. Passive Cooling of Buildings, Athens, pp53-59*
6. Dubiel J, Wilson M, Nicol F. (1996) Decibels and discomfort- an investigation of noise tolerance in offices. *Proc joint CIBSE/ASHRAE conf. Harrogate Vol. 2 pp184-191*
7. Nicol F, Wilson M, Dubiel J. (1997) Decibels and Degrees-interaction between thermal and acoustic interaction in offices. *Proc CIBSE National Conference*
8. McCartney K and Nicol F, (2001) Developing an adaptive control algorithm for Europe: results of the SCATS project, *Proc Moving thermal comfort standards into the 21st century, Windsor,*
9. Solomon J, Wilson M, Wilkins P, Jacobs A. (1998) An Environmental Monitoring System for Comfort Analysis *Proceedings of EPIC'98, Lyon, pp457-462 ISBN 2 86834 1160*
10. http://www.unl.ac.uk/LEARN/port/1997/scats/scats_index.html
11. Kang J. (2000) Modelling the acoustic environment in city streets. *Proc PLEA 2000, Cambridge pp 512-517 ISBN 1-902916-16-6*