ADDEY + STANHOPE SCHOOL ACOUSTIC DESIGN OF A NEW TEACHING BLOCK: A CASE STUDY

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1 INTRODUCTION

The acoustic design of a new teaching block in Addey + Stanhope School in Deptford is discussed with respect to exclusion of external traffic noise for naturally ventilated rooms. The new extension is adjacent to a heavily trafficked city road. The road is a two lane highway and is the main source of noise in the area. BAP's tasks related to the sound insulation of the building envelope as well as the acoustics of classrooms with regard to their reverberant and background noise conditions. The exclusion of external noise involved consideration of the construction of the external envelope (walls, windows, roofs) and the provision of ventilation. In the main spaces under consideration, ventilation was provided using a windcatcher system, which is a system of natural ventilation utilizing shafts which supply and discharge air via an air stack which terminates on the roof.

The present study presents the design criteria used and compares the predicted results during the design process with the ones that were measured during a post-completion acoustic testing carried out on site.

The results indicate good agreement between prediction and measurement and demonstrate that it is possible to provide natural ventilation on a noisy urban site and meet the noise limits in Building Bulletin 87[1].

2 CRITERIA

The acoustic design was based on the noise limits recommended by DfEE Building Bulletin 87[1] (BB87), of 40 dB $L_{Aeq\ 1h}$ in classrooms and not more than 50 dB $L_{Aeq\ 1h}$ in a Gymnasium. (These limits are now superseded by more stringent limits in BB93[2]. The new upper limits for indoor ambient noise levels as recommended by BB93 are, 35 dB $L_{Aeq\ 30min}$ in classrooms and 40 dB $L_{Aeq\ 30min}$ in a Gymnasium).

3 NOISE SURVEYS

Noise surveys were carried out on site prior and after the completion of the new teaching block extension. The aim of the surveys was to establish the ambient noise level the school's building envelope would be exposed to. This would form the basis for the establishment of the sound insulation requirements of the building envelope.

The surveys gave very consistent results, indicating an ambient noise level of 70 $L_{Aeq\ T}$ (free-field) at the position of the nearest building façade. The major source of noise is traffic noise from the very busy New Cross Road. (Figure 1 shows a Site Plan indicating the measurement locations).The rooms which are most exposed to road traffic are:

Ground Floor: Gymnasium

First Floor: Languages Classrooms 1, 2 and 3

Second Floor: Mathematics Classrooms 2, 3, 4 and 5 and ICT rooms 1 and 2

The nearest building façade to New Cross Road is the façade of the second floor of Mathematics 4 and ICT1. The Second floor plan can be found in Figure 2.

4 ACOUSTIC DESIGN

The exposure on to various parts of the building envelope were calculated by extrapolation from the baseline noise measurements, by reference to the Calculation of Road Traffic Noise (HMSO). Design calculations of future internal levels were made on an iterative basis, by developing the acoustic specification of windows, roof and the windcatcher system in turn until the overall internal limits given in Table 1 were met.
The final envelope constructions were as follows:

Walls: part brick/block cavity, part blockwork with terracotta tile rainscreen and mineral fibre in the cavity.

Windows: Double glazing incorporating 10mm and 6.4mm laminated glass with a 12mm cavity

Main roof: proprietary double skin steel roofing system (38 dB R_w)

Mansard roofs: proprietary roofing system, supplemented by an internal plasterboard lining with mineral fibre infill.

Roof lights (small): Double glazing incorporating 4mm glass.

4.1 The Ventilation System

One of the weak points when considering the sound insulation of any building envelope, is the necessary provision of openings for ventilation. These openings are inlets and outlets on the façade or the roof of the building for a mechanical or a natural ventilation system.

Due to close proximity of the classrooms to the road, opening of windows as a method of rapid ventilation was not considered appropriate because of the high level of noise and the airborne pollutants emitted by the heavy road traffic. Hence, alternative ventilation methods were considered. It was therefore decided, that the rooms most exposed to the traffic noise are to be ventilated using a windcatcher system (Figure 3) with the exception of the premise's manager's office which will be provided with a noise – attenuated ventilator unit. These units were originally developed to comply with the requirements of the Noise Insulation Regulations 1975[3] (These Regulations apply to dwellings affected by noise from new or improved roads). They comprised a variable speed powered ventilator which is designed to be installed in the building façade and a permanent air vent or a single unit that combines both. There are normally two speed settings and the Regulations set limits on noise transmission through the units and the self-noise of the fan.

4.2 The Windcatcher System

It was decided that all new teaching spaces will be naturally ventilated by a "windcatcher" type system through terminals mounted on the roof. These roof terminals are designed to be omnidirectional allowing the intake of fresh air regardless of the prevailing wind direction. Each terminal is divided in equal quadrants; two are positively pressurized by the wind to create a fresh intake; the remaining two are negatively pressured allowing air to be exhausted (Figure 3). Each terminal can be carefully sized according to the volume of the space to be ventilated, the number of people who will normally occupy the space and any potential source of additional heat. Each terminal is individually controlled by dampers set in the ends of the duct.

In-principle recommendations were given for the attenuation of noise as it passes through the windcatcher system. It was recognised that implementation of attenuation measures may affect the airflow characteristics and therefore any suggestions would need to be confirmed by the manufacturer before implementation. Initial calculations indicated that a lined section of duct of 5m length would reduce the road traffic noise to around 40 dB(A) in a classroom.

The windcatcher system manufacturer arranged for acoustic tests to be undertaken in BRE Laboratories. A number of different internal lining treatments to the windcatcher system were tested. The results are summarised in the table below:

Test Details	**$D_{n.e.w}$ ($C;C_{tr}$) (dB)**
620mm x 620mm square hole in filler wall	13 (0;0)
Vent, unlined with dampers open	16 (0;0)
Vent, unlined with dampers closed	26 (0;-1)
Vent lined with acoustic tile*, dampers open	26 (0;-3)
Vent lined with acoustic tile*, dampers closed	35 (-1;-5)
Vent lined with open cell foam**, dampers open	26 (0;-3)
Vent lined with open cell foam**, dampers closed	35 (-1;-4)
Vent lined with open cell foam**, linear ceiling grille fitted	27 (-1;-4)

*Armstrong Tatra BP952 M3B, approximately 20mm thick
**Soundsorba foam. Approximately 20mm thick

For the classrooms located on the 2nd floor level, the windcatcher ducts were not long enough and it proved necessary to enhance the attenuation by fitting an additional attenuator (Figure 3 and 4). For classrooms located at the lower floors the length of the lined windcatcher duct is much increased and no additional attenuator was required. The final arrangements are summarised in the following table.

Classroom	**Floor**	**Max internal noise limit, dB(A)**	**Treatment**
Mathematics Classrooms 2, 3, 4 and 5	2	40	Internal acoustic lining plus 500mm attenuator
ICT rooms 1 and 2	2	40	Internal acoustic lining plus 1800mm attenuator
Language Classrooms 1, 2 and 3	1	40	Internal acoustic lining
Gymnasium	Ground	50	Thermal insulation only to blockwork ducts

Table 1: Recommended Upper Limits for the Background Noise in the Unoccupied Spaces

5 POST – COMPLETION MEASUREMENTS: INTERNAL NOISE LEVELS

Following completion of the building, measurements of the internal noise limits were carried out in a number of rooms. These measurements were averaged over a number of locations in each room, whist a simultaneous measurement external noise was made. The external free-field $L_{Aeq,5hrs}$ was found to be 70.6 dB, which was within 1 dB of the results obtained prior to development. The detailed measurement results are summarised below where they are compared with the design targets and predicted values.

Room	**Design target dB, $L_{Aeq,1h}$**	**Calculated dB, $L_{Aeq,1h}$**	**Measured dB, $L_{Aeq,1h}$**	**Comments**
Gymnasium	50	45	42	Major flanking around Escape Door
Languages 1	40	37	38	
Languages 3	40	40	43	Some window frames not yet sealed
Mathematics 2	40	39	38	
Mathematics 3	40	40	38	
Mathematics 4	40	41	41	
ICT 1	40	42	44	Computer noise dominant
ICT 2	40	33	42	Computer noise dominant

Table 2: Comparison between the design target, the calculated and measured internal noise levels.

The measured results in the Gymnasium, Languages 1, Mathematics 2 and Mathematics 3 were found to meet the design limits. Excesses over the design limit in Languages 3, ICT 1 and ICT 2 can be explained by the factors noted in the comments column, i.e. excessive noise transmission via temporarily unsealed window frames and the noise from computer fans in the operational ICT rooms. The very small excess of 1 dB in Mathematics 4 was in line with predictions.

Internal noise measurements were also carried out the with ventilation system open and closed. The results did not display any significant change in level. Nor was there found to be any significant variation in level around the room, indicating that the ventilation system does not appear to be the limiting factor for sound insulation, even with the dampers open.

6 CONCLUSION

This case study illustrates that a noise reduction of at least 30 dB(A) can be achieved through the envelope of naturally ventilated classrooms, if a sound attenuated passive stack ventilation system is used and suitable building envelope constructions are specified.

7 REFERENCES

1. Building Bulletin 87 “Guidelines for Environmental Design in Schools, 1997, DfEE.
2. Building Bulletin 93 “Acoustic Design of Schools, 2003, DfES
3. The Noise Insulation Regulations 1975, Statutory Instruments 1975/1763, Building and Buildings

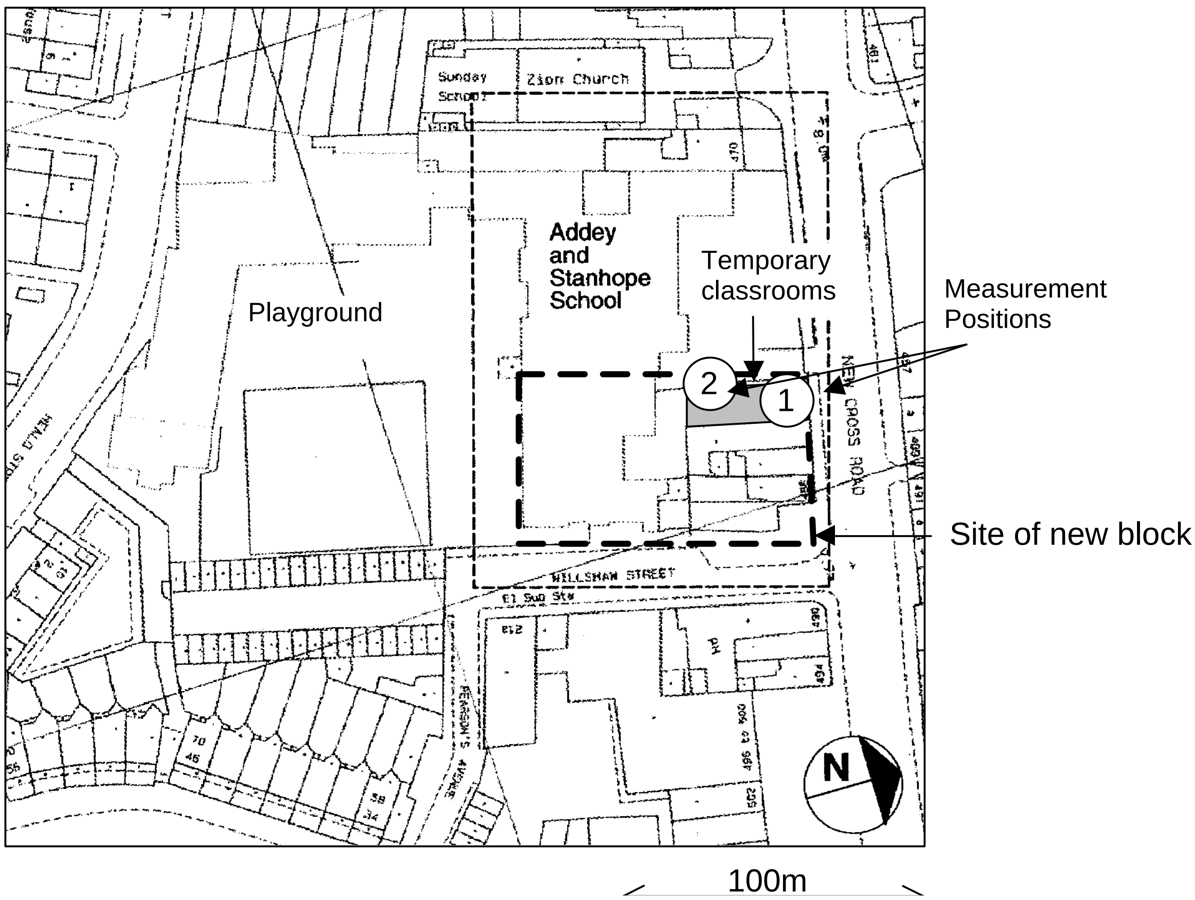

Figure 1: Addey + Stanhope School: Site Plan. The measurement positions are Indicated

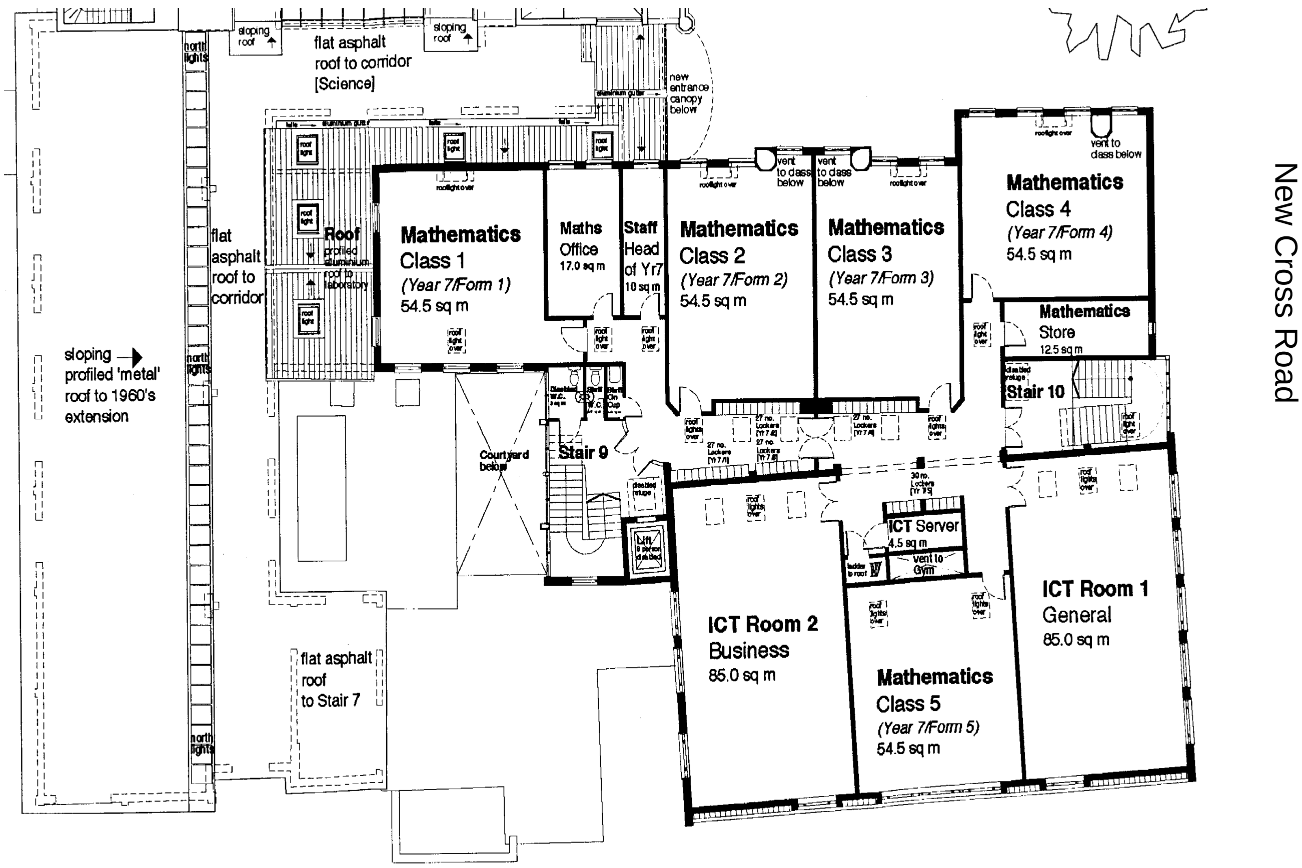

Figure 2: Addey + Stanhope School: Second Floor Plan

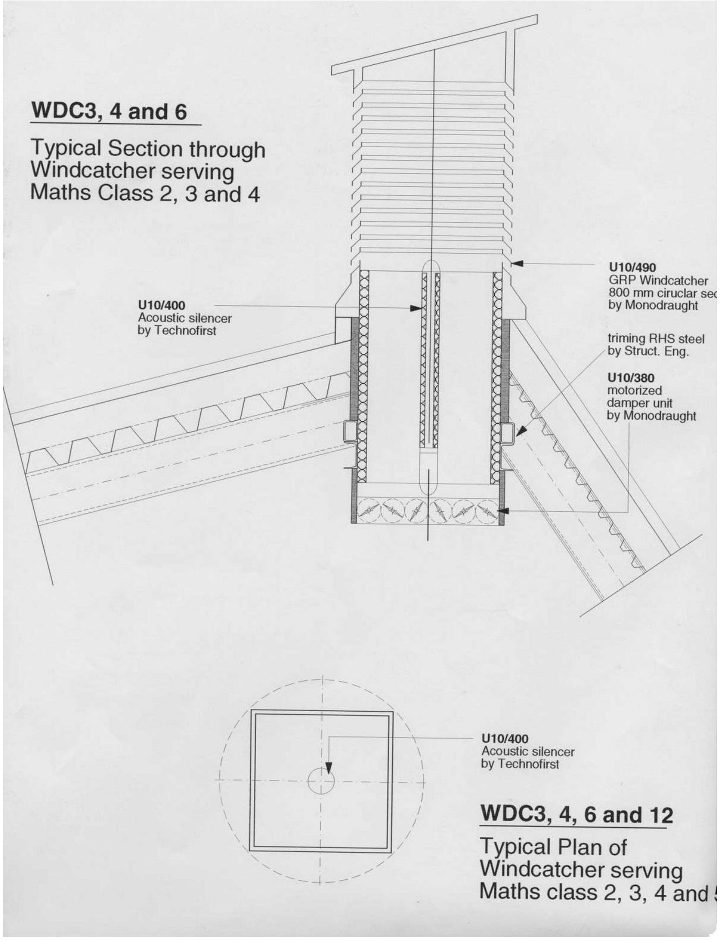

Figure 3: Indicative Typical Section Through Windcatcher Serving Mathematics 2, 3 and 4 (not to

Typical Dimensions:	Circular or square section: 800 mm – 1200 Intake Louvre: 625 – 1250mm high Length of Internal Lining: 1200 - 1400mm

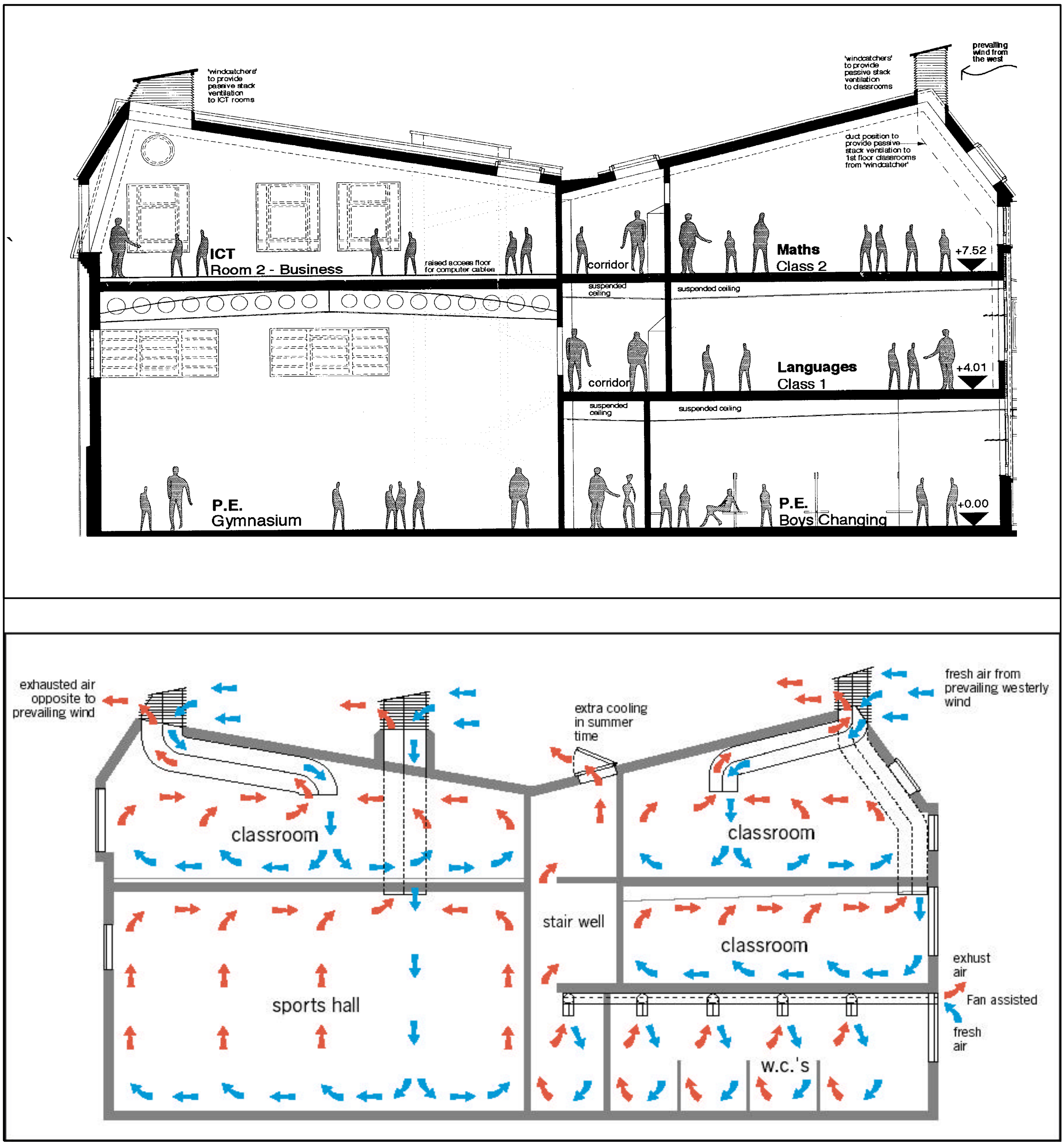

Figure 4: Addey + Stanhope School: New Teaching Block, Section. (The stack ventilation in operation is indicated)