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DESIGNING FOR NATURAL VENTILATION: LAW COURTS

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There is considerable interest in possible designs for naturally ventilated Law Courts, which avoid the need for air conditioning. However, design requirements make it difficult to locate windows for ventilation purposes. A proposed alternative is based around the concept of providing summertime ventilation via an underfloor duct and controllable vents at roof level, under the action of wind and buoyancy forces alone. This option was assessed through a computer study to predict the ventilation flows into several variations of a general court-room design over a range of meteorological conditions and internal temperatures. The ventilation performance during the summer months was assessed using a new statistical approach. Improvements to the performance of the above design are demonstrated by results for a proposed Crown Court complex to be built near Canterbury.

INTRODUCTION

There is considerable interest being shown in the possibility of building a series of Law Courts which will be naturally ventilated (Building Today (1)), thereby avoiding the need for air conditioning. Design requirements for the operation of the court, and for privacy and security, make it difficult to locate windows for ventilation purposes. Alternative options have been proposed, based around the concept of providing summertime ventilation via an underfloor duct and controllable vents at roof level, under the action of wind and buoyancy forces alone. The objective is to provide adequate fresh air for the occupants and sufficient summertime cooling to offset fabric and casual heat gains.

The number and variety of openings that need to be considered makes it difficult, if not impossible, to use existing 'design guides' (BSI (2), CIBS (3)) to predict whether the court-rooms will be adequately ventilated. Prediction has, therefore, to be done through computer modelling. This requires two items of building-specific input data - leakage characteristics of the building fabric and the distribution of wind pressures on its external surface. The ventilation characteristics of intentional openings (vents, windows and ducts) may be easily represented. Surface pressure coefficients are available from tables ((2), Liddament (4)) for simple building forms. For more complex buildings, however, an individual wind tunnel test is needed.

This report describes results from a computer study used to predict the ventilation flows into several variations of a general court-room design over a range of meteorological conditions and internal temperatures. This enabled an optimum design to be identified, and a new approach was used to assess its statistical ventilation performance over a typical range of meteorological conditions. An important feature is that it shows how often a given ventilation requirement would be achieved under local meteorological conditions. The example of a proposed Crown Courts complex is presented to show how the salient features of the general design could be modified to improve on this performance.

THE COURT DESIGNS AND MODEL REPRESENTATION

The courtroom is proposed to be on the third storey of a large building, at one side and away from the corners. The salient features of the design relevant to the computer model of the ventilation (see Figure 1) are an underfloor duct to supply air from outside, and a roof structure projecting above the surrounding building roof level with openable windows (each 0.75 m^2 free area) in the four vertical sides and a horizontal vent in the top.

VENTILATION PREDICTION

The computer program comprises of equations relating the airflow through each type of ventilation opening to the pressure difference across each opening. These pressure differences depend on the wind speed and direction and on the pressure coefficients exterior to the opening, and also on the temperature difference between the air in the room and that outside ((Perera and Walker (5)). The room air pressure at ground level is the unknown parameter to be determined. Pressure coefficients were estimated from published literature (Shaw (6)) for winds blowing from each of twelve directions, at 30 degree intervals. Results were computed in the form of the ventilation flow for each wind direction, for a range of wind speeds and for all likely external air temperatures.

OPTIMUM CONFIGURATION AND STATISTICAL ASSESSMENT

Downflow, out through the duct ('flow reversal'), was predicted for some conditions. In the vicinity of these conditions, flow would be nearly stagnant. This result occurred less often with the roof vent closed combined with a control scheme to close the windward vent, which was therefore taken as the optimum configuration. The effects of independantly increasing the height of the court, reducing the flow resistance of the duct, relocating the duct intake at the corner of the building, and increasing the size (area) of open vent were also studied. Only the latter was found to be significant, i.e. the vent sizes were the controlling features.

The ventilation prediction carried out above, though specific to the court-room, makes no reference, however, to the local meteorological conditions expected at the site. Since the ventilation characteristics of the court-room are determined both by wind pressure and buoyancy forces, the performance over a period of time depends on the joint occurrence of wind speed, wind direction and outside air temperature. A reference data set of this type was obtained for Kew from the Meteorological Office.

Polynomial curve fits were computed for a compressed form of the results (Warren and Webb (7) and (8)), in which the temperature dependance had been removed. These curves were then used to determine the duct flow Q_d for all combinations of wind speed and outside air temperature, for given internal temperatures. The associated percentage occurrence of each duct flow was used to build up a probability distribution over all twelve wind directions. For example, Figure 2 shows the results for either an urban or suburban location, for an internal temperature of 19°C. From these results it is a simple step to determine the percentage of time that flow from the underfloor duct and out through the high-level vent exceeds the requirement for typical and full occupancy of 1,000 and 2,000 m^3/h for 70% and 60% of the time respectively, as summarised in Figure 3. When the direction of flow through the duct is ignored, the frequency of exceeding the requirement is greater (see Figure 3).

PROPOSED CROWN COURTS

Based on the above design, a Law Courts Complex (5), comprising of several Crown Courts and one County Court, is to be built near Canterbury. Figure 4 shows a schematic of one of the court rooms. Detailed measurements of pressure coefficients using a scale model in a wind tunnel showed that the performance of the design was improved by positioning the duct intake in a more sheltered location near to the ground. By combining the results with the local meteorological data in a suitable way as above, it was predicted that the ventilation requirement for either full or part occupancy would be met for about 90% of the time for an internal temperature of 21°C (see Figure 5). If the internal temperature rises to 25°C, the increased buoyancy effect causes adequate ventilation nearly all the time that the court is occupied.

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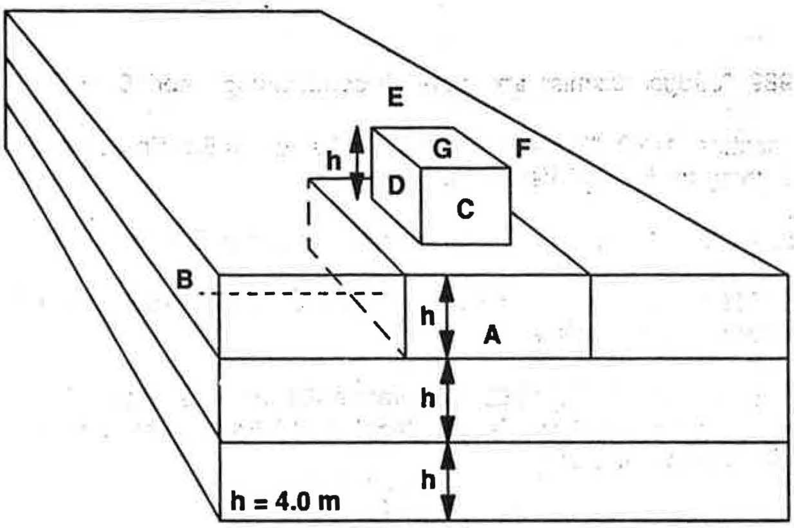
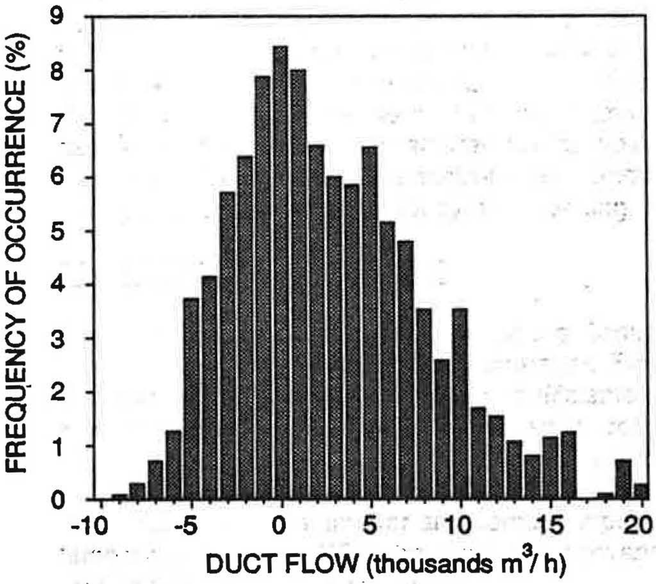


A duct intake
B alternative location of duct intake
C,D,E,F side vents
G roof vent

Figure 1 Salient features of court



Court located in urban or suburban terrain
Internal temperature 19°C

Figure 2 Frequency of occurrence of intervals of duct flow (inflow is positive)

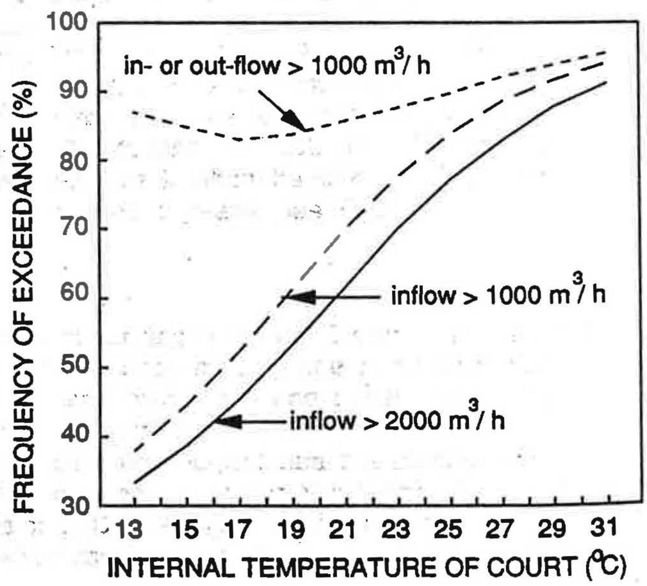


Figure 3 Frequency of exceedance of ventilation requirements

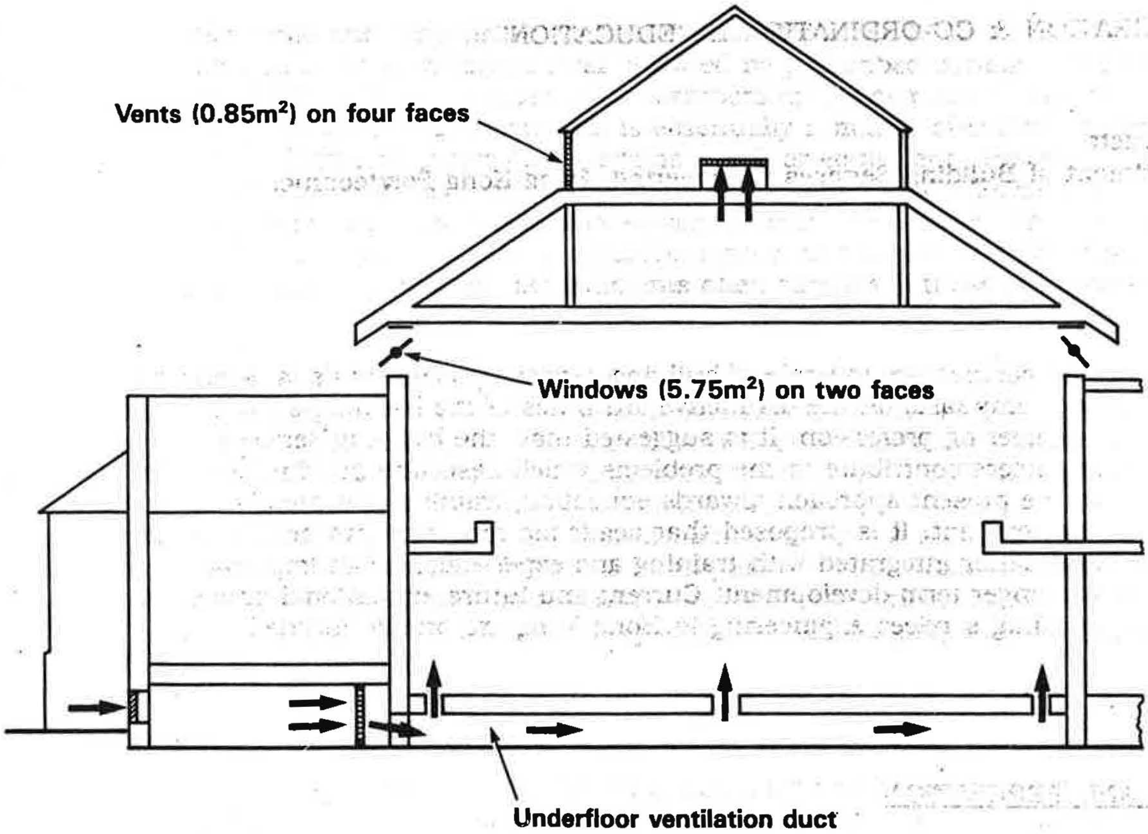


Figure 4 Schematic of Canterbury Court

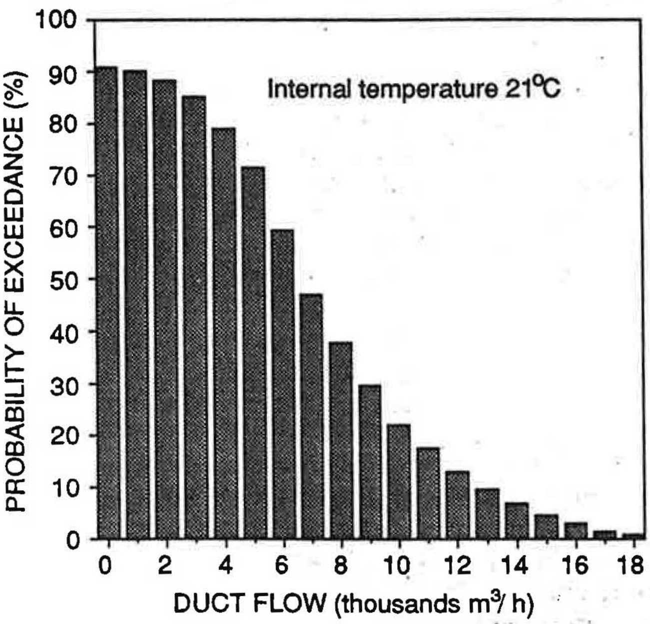


Figure 5 Frequency of exceedance of intervals of flow in through the duct