E. Pihl & Son Headquarters, Lyngby

Building Description

The company Headquarters of E. Pihl & Son (one of Denmark's major contractors) is located in relatively quiet surroundings in Lyngby about 10 kilometres north of Copenhagen City. Completed in 1993/94, the building is, in concept, a three-storey office building angled in a diagonal symmetry in which the sides of the angle reflect each other. The corridors are sky-lit galleries and formed as a panopticon space. A canteen extends out from one of the wings. Figure 1 illustrates the north-west facade of one of the office wings.

Figure 1: Outside View of Headquarters Building

The facade of the building is brickwork and glass while the roof and the internal walls are in-situ concrete. Generally the internal concrete walls and ceilings are exposed, and the thermal mass of the building can be characterised as heavy. Internal steel frames support skylights, stairways, fittings and other permanent furnishings. The windows and the glazed facades are made from reflective glass.

Figure 2 shows a typical floor plan. The floor area is about 2,700 m^2 and the building volume is 8,000 m^3. About 2,000 m^2 (75%) is used for offices and meeting rooms, 400 m^2 (15%) is circulation area and the remainder is toilets and cloakrooms (100 m^2) and the canteen (200 m^2).

The activity in the building is mainly administrative. On the second floor, above the two-storey foyer, there is a drawing office containing equipment and machinery for producing and folding up blueprints. Conventional, commonly used office machines such as faxes, photocopiers etc. are placed in separate rooms on each floor.

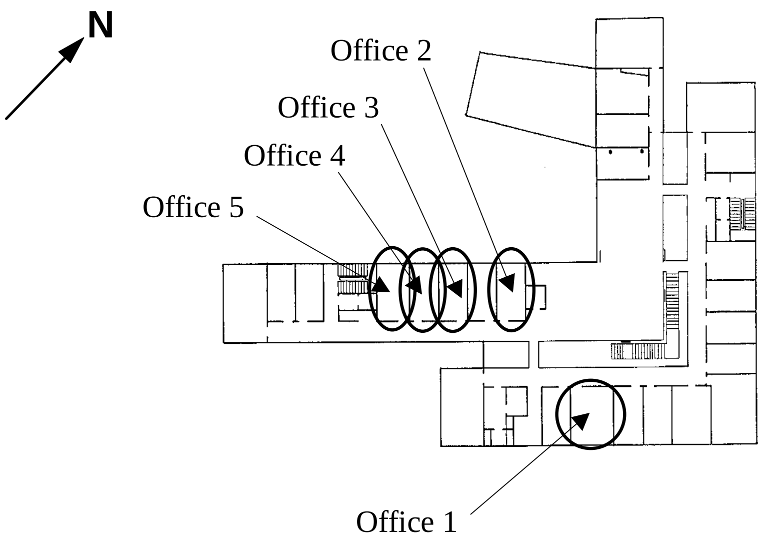

Figure 2: Typical Floor Plan Showing Offices Monitored

Ventilation Philosophy and Aims

This building has given rise to much interest among architects. In 1994 it was nominated for the Mies van der Rohe Prize and the building owner was awarded a Danish architectural award, DAL/AA's Kaleidoscope of Honour. However, the building is also very interesting from an engineer's point of view. E. Pihl & Son required an office building of high quality with technical installations that were simple and hidden, yet effective and advanced. The building is specifically designed for natural ventilation, except for the toilets, cloakrooms and service areas. As part of the ventilation design stage, the architects and engineers took into account both wind and temperature (stack) generated pressures. Knowledge and ideas from traditional buildings in the tropics were taken into consideration including the principles developed for the Danish pavilion at the Seville fair.

Ventilation Technology

Although the ventilation principle is extremely simple, the "intelligent house" control system (known as I-BUS) is highly complex. This system handles not only the ventilation, but also the heating

Architect: KHR A/S
Ventilation design: NNR A/S
Research team: Danish Building Research Institute

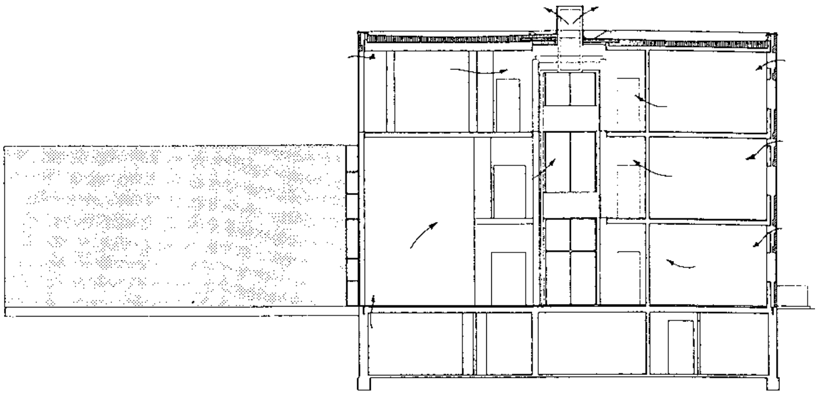

Figure 3: A Sectional View of One of the Office Wings

system, artificial lighting and solar shading There are internal blinds in the offices. Mechanical ventilation is provided in the meeting rooms, toilets and canteen. In the two-storey foyer there is mechanical air supply in the floor along the glazed facades.

The offices are naturally ventilated, the main components being specially designed multi-position ventilation openings in the offices and openable skylights in the corridors. Figure 3 illustrates a sectional view of one of the office wings including idealised air flow paths. The ventilation openings in the offices are located in distinctive narrow window bands above the ordinary windows, as shown in Figures 1 and 4.

In order to take advantage of night time cooling and outdoor air supply, the ventilation openings and the openable windows in the skylights are motorised and automatically controlled via temperature sensors. Two extract fans, located on the roof of the building as an integrated part of the skylights, are intended for use in case the natural driving forces are insufficient. The fans are activated when the internal temperature reaches 26^{o}C (Figure 5).

Artificial lighting is controlled from outdoor light sensors and at least one sensor for occupancy in each office. The sensors in the offices are located in a panel near the facade below the windows.

Monitoring Programme

Five offices on the second floor were chosen for the investigation, as identified in Figure 2. Office 1 is a relatively large cellular office (20 m^2), office 2, 3 and 4 are cellular offices of equal size (14 m^2) and office 5 is a larger office (16 m^2) accommodating two people. Offices 1, 2, 3 and 5 were included in the summer monitoring exercise. In the winter monitoring exercise, offices 3, 4 and 5 were investigated as well as the corridor adjacent to the offices.

Summer Monitoring Results

Figures 6 summarise the results of the summer monitoring exercise for office 2.

Thermal comfort and air quality: During the summer monitoring period, problems with the control system were encountered. The automatic opening of both the skylights and the ventilation openings in the offices was found to be unreliable, leading to inefficient night-time cooling and hence, elevated temperatures in the offices from early morning, particularly during periods of hot weather. However the CO_2 level was well below critical limits indicating that sufficient ventilation was provided to meet indoor air quality needs.

Figure 4: View From Inside an Office Illustrating Narrow Window Bands Above the Main Windows

Figure 5: Location of Extract Fan and Open Roof Light

Winter Monitoring Results

Figure 7 summarises the results of the winter monitoring exercise for Office 5.

Thermal comfort and air quality: When the building was occupied, the indoor temperature in the offices reached about 23°C and the CO_2 concentration was between 800 and 1000 ppm. In office 5 (given here as an example) the outdoor air supply was between 2 and 4 l/s.m² (i.e. about 2-5 air changes per hour). During weekends the indoor temperature dropped to about 20°C, the CO_2 concentration approached the outside background level (400 ppm). Also, since the building was closed, the outdoor air supply was reduced to close to zero at weekends.

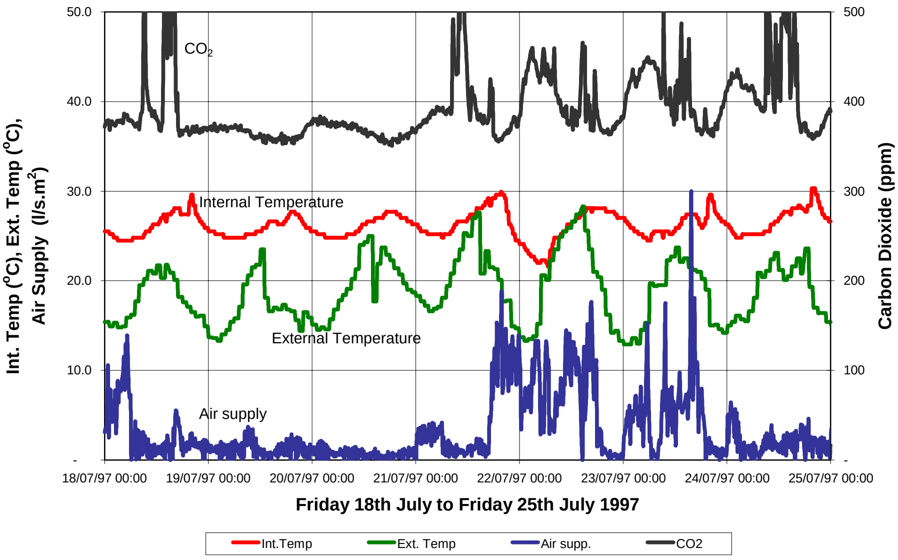

Figure 6: Summer Monitoring Results

Evaluation of Occupant Reactions

Figure 8 summarises the ratings of various environmental conditions from about 50 occupants during the summer monitoring period. Even though the night cooling arrangement, in general, did not perform as intended, the occupants expressed only limited dissatisfaction with the thermal environment. Presumably, the occupants themselves, together with the manager in charge of the technical installations, were able to manually control both the ventilation openings and the internal blinds and thereby quickly obtain acceptable conditions.

Figure 9 summarises the occupants' ratings of various environmental conditions in their office during the winter season. About 75 occupants responded.

Comparing Figure 8 and Figure 9 indicates that the occupants rated the indoor environment in the winter to be more comfortable than in the summer.

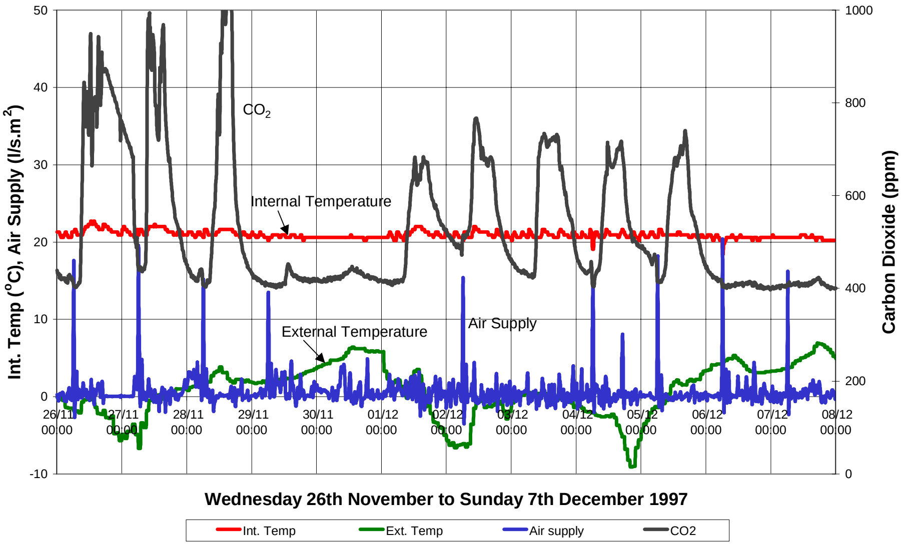

Figure 7: Winter Monitoring Results

The occupants' rating, both in the summer and in the winter situation, of the noise level is noteworthy. Generally, the occupants on the ground floor complained strongly about disturbing noise coming from the upper floors which was transmitted through the open space of the main foyer.

Lessons Learnt and Suggested Improvements

Generally the building performed well and there were no serious indoor air quality or over heating problems. The main difficulty was concerned with the automated controls, resulting in the night cooling approach not performing properly. Suggested improvements relate to improving the reliability of night cooling control system.

Also external shading is far more effective than internal shading for minimising solar gains. This, therefore, could be considered as a means to further minimise indoor temperature in the summer. Noise propagation proved to be a problem to some occupants and strategies to dampen noise transport from the open spaces is needed.

NatVent Case Study Summary

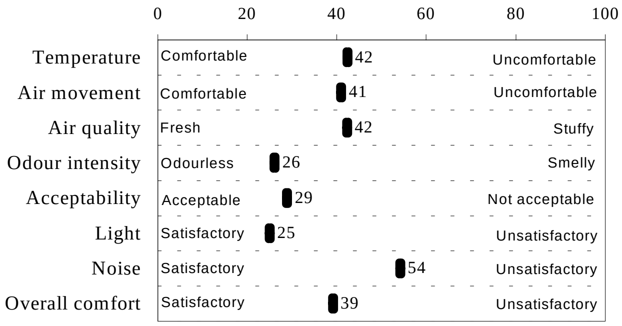

Figure 8: Occupant Reactions: Summer

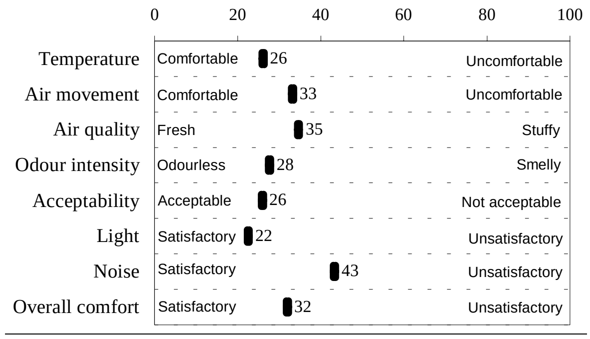

Figure 9: Occupant Reactions: Winter

Conclusions

This is a modern, large office building specifically designed for natural ventilation. As such there is no mechanical (refrigerative) cooling. The indoor environment was found to be generally satisfactory, even although control problems meant that full advatage could not be taken of the capacity for night cooling during the summer. At all times ventilation was found to be sufficient to meet occupant needs, while careful control of the ventilation rate during the winter (including closing the system down at weekends) meant that unnecessary heat loss was avoided. Despite reduced winter ventilation rates there were no significant odour problems reported and many occupants reported that the general comfort was very satisfactory. Noise propagation was however found to be a problem in some offices.

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The NatVent Project

Natvent is aimed at reducing energy consumption and carbon dioxide emissions by developing and demonstrating natural ventilation solutions. This project is targeted at climates in which overheating can be avoided by good architectural design and by minimising internal heat gains. By introducing natural ventilation, the complexities of mechanical systems and associated energy demand is eliminated, while the need for air conditioning is minimised. These case study summaries are intended to provide innovative examples of the use of natural ventilation and to demonstrate performance, pitfalls and solutions.

The NatVent Partners

Project Partners are:
Belgium: Belgium Building Research Institute,
Denmark: Danish Building Research Institute,
Netherlands: TNO Building Construction and Research, Delft University of Technology,
Norway: Norwegian Building Research Institute,
Sweden: J&W Consulting Engineers AB,
Switzerland: Sulzer Lab,
United Kingdom: Building Research Establishment, Willan Building Services.

European Joule Project

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