Zevenhuizen Town Hall, Zevenhuizen, ZH

Building Description

Zevenhuizen Town Hall (Figure 1) was built in 1987 and is owned by the municipality of Zevenhuizen. It comprises two storeys and has a total floor area of 1400 m^2 and a volume of 4200 m^3. The orientation of the building is N-S. There are various types of room including rooms for the mayor and aldermen, a meeting room and various offices for two to five people. Currently there are about 50 people working in the building but this number is increasing.

The building is a well insulated, low energy building of high thermal mass construction. The floors and roof comprise 0.25m thick concrete, the dividing walls between the corridor and hall are made from 0.15m thick concrete, and the dividers between rooms are gypsum plasterboard. In the hall and corridors the thermal mass of the ceiling and floor are exposed, but the office rooms have lowered ceilings and carpeted floors. The roof and facades are insulated with polystyrene foam.

Around the whole building are both openable and fixed windows in the walls and daylighting windows in the roof. The windows are double glazed with plastic frames. In the south-facing rooms the windows have internal curtains made from a light reflecting and transmitting fabric. When the curtains are down, they allow enough light (without glare) to be transmitted into the room so that no electric light is necessary, and they also reflect some light back through the windows to the outside.The daylighting windows do not have any shades. Office illumination is approximately 20 W/m^2.

Figure 1: View of Zevenhuizen Town Hall

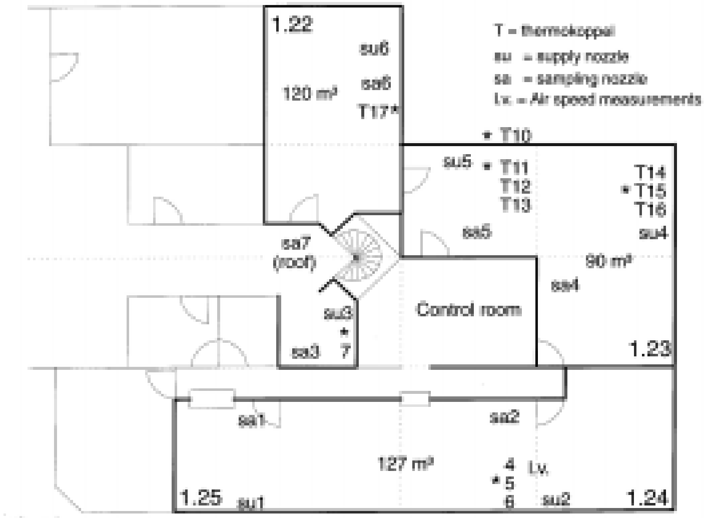

Figure 2: Monitoring Scheme

In the corridors and hall the original lighting has been replaced by high efficiency, low energy lighting.

Ventilation Philosophy and Aims

Fresh air is supplied to the building through the openable windows and stale air is removed from it by a mechanical air exhaust system in the roof.

The exhaust fan is operated at a low speed in winter to provide minimum ventilation for occupant metabolism. In the summer it operates at maximum speed to provide night cooling. The system is set to operate automatically. The air intake for night cooling is through one automatic window in the roof and open windows on the first floor north and north-east facades.

Part of the ventilation strategy for summer is to reduce the amount of heat generated inside the building from electrical equipment. The co-operation of the occupants is important and they are asked to switch off unnecessary lights and any electrical apparatus which is not in use. In addition, when the weather is hot, windows are left open at night to allow cooler air to enter and closed in the morning after 10 am (or when the outside temperature exceeds the inside

Architect: Becka, The Hague, NL
Ventilation design: Donkers & Hoogendoorn, Zeist, NL
Research team: Delft University of Technology

temperature), to restrict the flow of hot air into the building.

Ventilation Technology

The intake ducts of the exhaust channels are situated in the ceiling near the daylighting windows, see Figure 3. The mechanical ventilation system has three speeds: the lowest is used for minimum ventilation in winter and the highest is used in summer for night cooling.

Summer Ventilation Strategy: In the summer, the mechanical extract system works at its maximum capacity of 6500 m^3/h during the night to provide night cooling. The night ventilation is activated when the indoor temperature is above 21°C and the difference between the indoor and the outdoor temperature exceeds 3K. When these conditions are met, the ventilators run at full capacity after office hours. In the roof is a louvre window that is automatically opened to prevent an under pressure in the building in case all the manually operated windows are closed. The summer situation is 'on' when the boiler is turned off.This can be done manually by lowering the thermostat setting on the boiler.

Winter Ventilation Strategy: The mechanical extract system is operated at its lowest speed (3000 m^3/h) in the winter for minimum ventilation during working hours. This should provide sufficient ventilation for occupant metabolism and to dilute metabolic pollutants such as carbon dioxide and odours.

Figure 3 Daylighting Window Near the Intake Ducts of the Exhaust Channel

Monitoring Programme

During the summer of 1997 and the winter of 97/98 four rooms on the first floor of the west wing were monitored. Figure 2 shows the monitoring scheme.

The parameters measured were the indoor and outdoor temperatures, CO_2 concentration and ventilation rate in the rooms. The CO_2 concentration and ventilation rate were measured with a modified Brüel and Kjær gas analyser. Although wind velocity and solar radiation were not measured for this building, an indication of the weather conditions can be obtained by using weather data from the Rijswijk project (NL1). In each room three indoor temperatures were measured. These were the air temperature at 0.10 m and 1.10 m from the floor and the wall temperature. The air temperature was measured by putting the temperature probe in a black ping-pong ball. Before the start of the summer monitoring in June a questionnaire regarding the working environment was distributed to the people working on this floor.

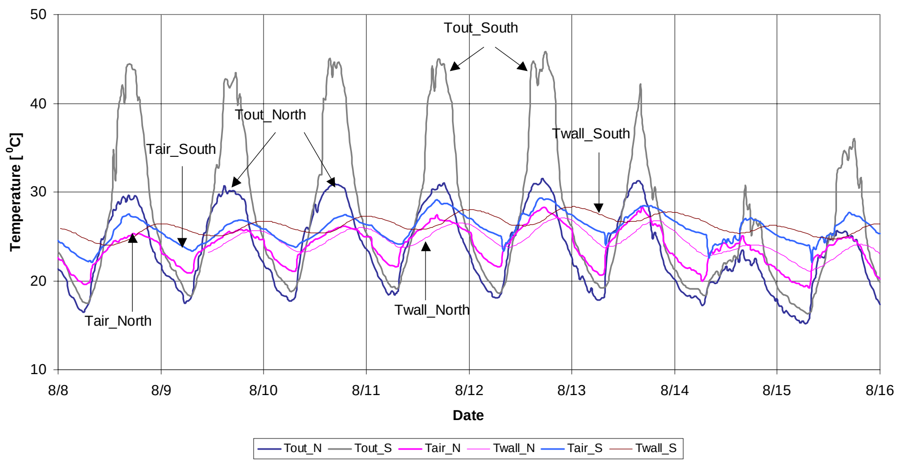

Figure 4: Monitoring Results for a Very Hot Week in August

Summer Monitoring Results

Figure 4 shows the results for the hottest period in 1997 (8th to 12th August). Outdoor temperatures did not fall below 15°C during this period. The outdoor temperatures differed for the south and north facades. On the south façade, the temperature sometimes reached more than 40°C on very bright days because solar radiation was reflected by the flat roof in front of the façade. The wind speed was low (0-5 m/s). Peak temperatures occurred very late in the afternoon. There was a great difference between a north and a south room: in the morning the north room heated up quickly and its temperature was comparable with that in the south-facing room. In the afternoon the temperature of the south-facing room continued to rise, while the north-facing room had already started to cool down. At night the north-facing room cooled down much faster than the south-facing room. Consequently, the cooling power of the wall in the north-facing room was higher than that in the south-facing room.

Summer Ventilation: Figure 5 shows the results of a summer monitoring period (25th September to 2nd October). The outdoor temperatures show the same patterns as before with very high temperatures on the south façade due to reflections from the flat roof just in front of the south façade. Indoor temperatures in the S-room were also higher than temperatures in the N-room. At the weekend (27th and 28th September) the temperatures were the same. Analysis of the weather data showed that the Saturday was very cloudy, while on Sunday the sun shone very brightly. Monday and Tuesday were cloudy days and so there was no solar reflection from the roof. However, the indoor temperature of the S-room still showed an increase. This can only be explained by the high internal load in the S-room.

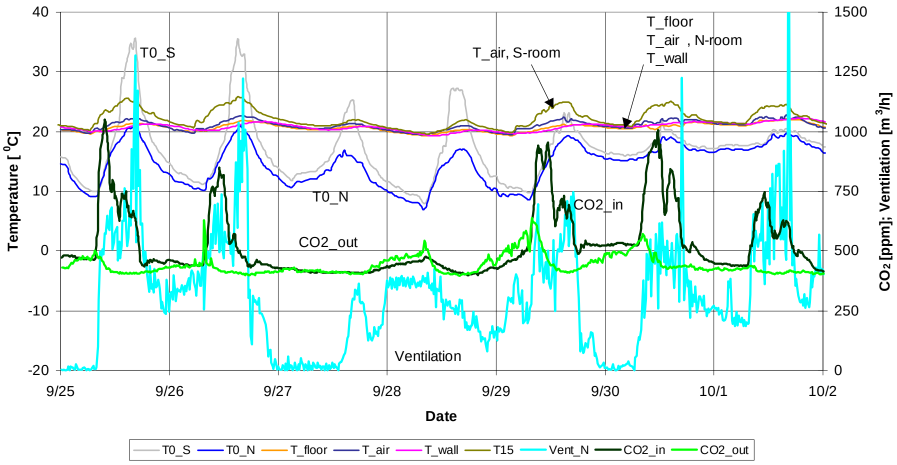

Figure 5: Summer Monitoring Results

The background (outdoor) CO_2 concentration was approximately 400 ppm while the indoor CO_2 concentration increased during working days to 750 ppm. Occasionally it rose to 1000 ppm. At night and during weekends the concentration very soon dropped again to the background level. These results indicated that the ventilation is adequate. Rooms 1.25 and 1.24 are, in effect, one room with a volume of 127 m^3, so the monitored ventilation for these two room numbers has been added together. During working hours the ventilation rate in the north room varied between 4 and 5 ach. The ventilation rate of the south room with a volume of 90 m^3 (the ventilation rates for rooms 1.23w and 1.23s were also added together) was much higher and varied between 6 and 10 ach.The ventilation rate outside working hours (18:00-08:00) was much lower at 3 ach for both rooms.

Figure 6 shows the distribution of the indoor air temperature during office hours (8:00-18:00, including the weekends) in August for the four monitored offices. Overheating has been analyzed in terms of the number of hours that the indoor temperature exceeded (a) 25.5ºC and (b) 27.5ºC. These results are summarized in Table 1. As illustrated, the rooms on the north side are much cooler with fewer overheating hours than the rooms on the south side. The lowest temperatures occurred in rooms 1.25 and room 1.23s.

	Hrs>25.5ºC	Hrs>27.7ºC
Room1.25	38	5
Room1.24	58	7
Room1.23s	114.5	33.5
Room1.23w	121	29

Table 1 Overheating Hours

Winter Monitoring Results

Figure 6 shows the results of the winter monitoring. This winter was one of the mildest winters ever experienced in The Netherlands. The wind speed was also very low. As with the summer monitoring, the ventilation rates for rooms 1.25 and 1.24 were added together. The mean ventilation rate during working hours was between 2 and 4 ach for the north room and between 6 to 8 ach for the south room.

The indoor CO_2 concentration was very acceptable during office hours. It never exceeded 1000 ppm. At night and at the weekend it dropped to the background level.

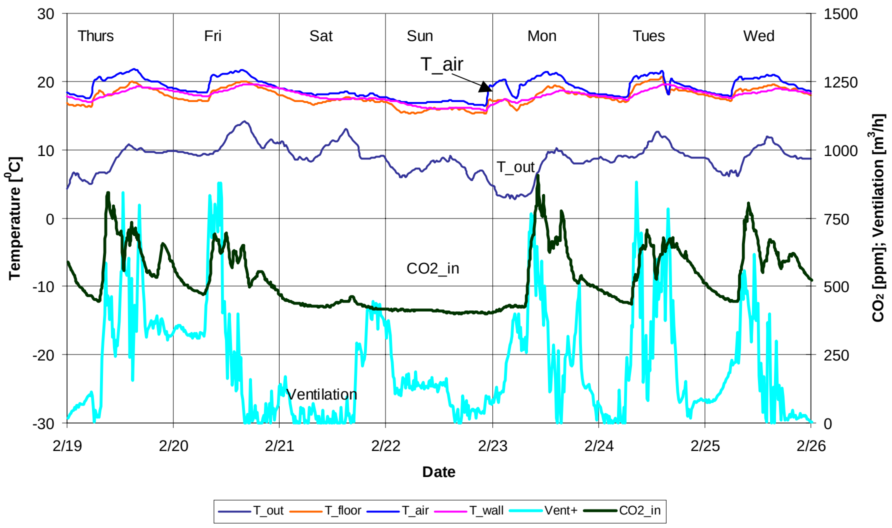

Figure 6: Winter Monitoring Results

Evaluation of Occupant Reactions

Ten people returned the questionnaire, four female and six male workers ranging in age from 24 to 55 years. All of them were non-smokers. The respondents worked in multiple occupancy office rooms of between five and ten people.

The Work Environment: Five people had significant control of their heating while the remainder had very little control. Control of ventilation varied from no control at all to full control. Most people had complete control of lighting. The workstations were all near a window (0-1 m) except for one, which was about 3 m from a window. Everyone used the windows. Four people had no complaints about the heating or ventilation. Of the others, some complained that there was no optimal indoor control in the building, which made it too hot in some places; some reported that it was too cold in the winter; and others that indoor temperatures were uncomfortable. Some thought that daylighting could be improved to reduce glare on the monitors.

Environmental Conditions: Four people found the indoor temperature ‘comfortable’, two ‘just comfortable’, two ‘too cold’ and two ‘too hot’. Six people found the air movement ‘comfortable’, three ‘just comfortable’ and one ‘uncomfortable’. Five people found the air quality ‘good’ (fresh and no smell), 5 between ‘fresh’ and ‘stuffy’ and ‘odourless’ and ‘smelly’. Four found the lights satisfactory and six found the lights between ‘acceptable’ and ‘just acceptable’. Two were content about the noise level, six found it ‘just acceptable’ and two found it between ‘just not acceptable’ and ‘not acceptable at all’.

There were also some areas of dissatisfaction, which only occurred in one part of the building, or at a specific time. For example, it was often too cold at the start of the working day, especially after the weekend. Also, in the summer it was sometimes too cold in the north-facing rooms, because there was no sun, but in the south rooms it was very hot after 15:00 hrs, when the sun was shining straight into the rooms. Night ventilation was not sufficient to cool the building.

Lessons Learnt and Suggested Improvements

The following improvements are suggested:

- provide transparent sun shades for the daylighting windows
- provide automatic daylight dependent light switches
- reduce the general illumination level in some rooms
- provide a timer for the electrical equipment
- provide the computers with a standby position
- increase the capacity of the night ventilation
- increase the roof insulation

Conclusions

The ventilation system of this building has a maximum capacity of 6500 m^3/h; with a volume of 4200 m^3, this means an average ventilation rate of less than 1.5 ach in the summer for night ventilation and 0.3 ach for minimum ventilation. The measured ventilation rates were much higher: during office hours the ventilation rate in the north room was approximately 2-4 ach in winter and 4-5 in summer; the south room had a much higher ventilation rate of 6-7.5 ach in winter and 6-10 ach in summer

The overheating hours (T>25.5°C) during office hours were very low in the north rooms, with respectively 38 and 58 hours. The south rooms had much higher overheating hours, respectively 114.5 and 121 hours.

The CO_2 concentration was very acceptable at 750 ppm during working hours in the winter. In summer it occasionally increased, but was always below 1000 ppm. At night and during weekends the CO_2 concentration quickly dropped to the background level of 400 ppm.

The internal load had a marked influence on the indoor temperature.

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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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