Client Report :

Daylight and heat gain calculations for 12 office units at Eastern Road, Bracknell

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Executive Summary

This project was carried out for Bill Reed Architecture. It has investigated likely daylight and comfort conditions for 12 office units at Eastern Road, Bracknell

The scope of this work was to determine the optimum location, orientation, size, and quantity of Velux rooflights. The objective was to achieve the optimum balance between allowing natural light into the centre of the buildings, and minimising heat gains.

The final objective of this study was to verify that, for 95% of the typical occupied hours during the year, the internal comfort temperature would be 25°C or lower, to correspond with the percentage recommended by the BCO (British Council for Offices) for naturally ventilated buildings.

Dynamic thermal simulations were performed using state of the art computer modelling software (Apache, Facet) to predict internal air temperatures. These indicated the comfort conditions and the percentage of hours for which the air temperature would not exceed 25°C.

Thermal modelling was carried out for all 12 office units using appropriate hourly weather data, levels of internal gains, ventilation and infiltration losses, a night cooling strategy and the provision of external and internal shading

Finally the Average Daylight Factor (ADF) was also calculated for all 12 office units in order to ensure that the offices were well daylit.

Results from the dynamic thermal simulation show that the comfort temperature in all the 12 offices units could be maintained below 25°for 95% of the occupied time, as recommended by the BCO for naturally ventilated buildings.

The Average Daylight Factors (ADFs) were between 3.7% and 5.5% showing that good levels of daylight would be provided.

Contents

Introduction

This project was carried out for Bill Reed Architecture (BRA) to investigate likely daylight and comfort conditions for 12 office units at Eastern Road, Bracknell.

This report summarises the thermal comfort and daylight performance analysis for the twelve naturally ventilated office units. Daylight calculations were undertaken for all 12 office units in order to determine the optimum location, orientation, size, and quantity of Velux rooflights.

Comfort analysis was carried out using dynamic thermal simulation software. The results of the daylight calculation provided information on the location, orientation, size, and quantity of Velux rooflights to be installed. Other input parameters including the building orientation, geometry and building physical properties were specified in accordance to the description provided by BRA.

Other parameters included appropriate selected hourly weather data for the Bracknell site. The inclusion of internal shading (blinds) and shading from outdoor obstructions (trees) were also considered. Because the eventual occupancy of the spaces is not known at present, assumptions were used for the occupant density, internal gains, timing of gains and minimum ventilation rate. These were set at the BCO[1] (1994) recommended levels. Further details of the assumptions and parameters used, including the operation schedule and ventilation strategy are summarised in the model below.

Description of the project

To evaluate the comfort performance of each office room under occupied conditions, simulations were performed for each natural ventilated office unit, using the information described below.

The input parameters used are summarised as follows:

- Hourly climatic data for Bracknell (1994)
- Envelope elements (exposure, boundary conditions, thermophysical parameters,) for the building geometry see Figure 1, and Table 1 for the thermophysical properties
- Ventilation was considered to provide 12 litre/sec per person of fresh air during occupied hours
- Air infiltration due to building fabric leakage was constant all day.
- The heat gains due to lighting, occupants, internal equipment and appliances were scheduled to occur between 08.00 and 18.00 for all weekdays.

BUILDING MODEL DETAILS

Building location and climatic data

Location	Bracknell
Latitude	51.7 degrees
Longitude	0.0 degrees
Altitude	20.0 metres
Wind exposure	Normal
Haze factor	0.90
Ground reflectance	0.20

Weather reference Bracknell 1994 (Hottest recorded available)

Hourly climatic data for a whole year were used. This included:

- Outdoor air temperature
- Diffuse and direct intensity of solar radiation on the different glazing orientations, including the solar angles for Bracknell latitude
- Relative humidity
- Wind speed

The geometrical characteristics and orientation of the office units are shown in Figure 1.

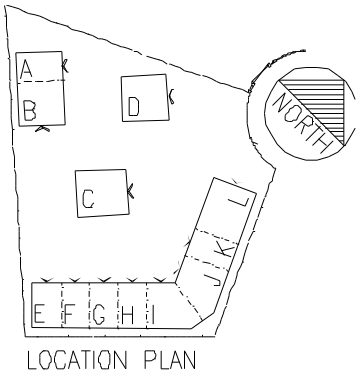

Figure 1: Location plan of the 12 office units at Eastern Road, Bracknell

Building thermo-physical properties

The U-Values of the construction materials comply with the current Building Regulations. Table 1 summarises the building physical properties used in the simulation.

Table 1. Building physical properties

Construction and materials		U-value
External walls:	***105mm brick (outer leaf), 60mm air gap, 54mm insulation, 105mm brick (inner leaf), 15mm plaster (lightweight)***	0.439 W/m^{2}K;
Louvres:	Louvres and insulated Doors	0.460 W/m^{2}K;
External walls Glass Blocks:	Glass Blocks, double glazing equivalent	0.280 W/m^{2}K;
Internal walls:	****105mm brick and 220mm brick (see drawing)***	*2.478 W/m^{2}K;
Floors/ceilings:	***200mm Hollow core Concrete slabs 150mm air, 38mm chipboard, 10mm carpet***	0.945 W/m^{2}K;
Ground floor:	***Insulated solid ground floor, 150mm cavity, 100mm polystyrene, 150mm Cast concrete, 65mm screed, 150mm air, 38mm chipboard, 10mm carpet***	0.219 W/m^{2}K;
Glass/Door:	***Framed double glazing. 6mm Cool-lite K coating SG, 12mm air, 7.5mm Laminated***	1.62 W/m^{2}K;
Rooflight:	***Framed double glazing. 4mm Toughened Low E, 14mm argon, 6.4mm Laminated***	1.700 W/m^{2}K;
Window:	***Framed double glazing 4mm Low E, 16mm air/argon, 4mm Float***	1.800 W/m^{2}K;
Roof:	***Pitched concrete tile roof, 150mm Rock-wool insulation, vapour barrier 9mm Beech soffit ceiling***	0.231 W/m^{2}K;

Light and solar transmission properties for glass are specified in the Annex .

OTHER GENERAL ASSUMPTIONS FOR ALL OFFICE UNITS:

Internal gains

Occupants:
An average occupation density over the entire space of 14m^2 /person.

Average total (sensible and latent) heat gain from the occupants of 140 W/person, of which 90W is sensible and 50W is latent heat.

Lighting:
Office areas: Internal gains from lighting of 12 W/m^2.

Equipment
Office areas:
Heat gains due to IT equipment (including computers, printers, photocopiers) of 8 W/ m^2.
Heat gains due to miscellaneous equipment of 8 W/ m^2.

Timing of gains
Figures 2 and 3 show the operating schedules for the buildings. All schedules are for weekdays only, with no use of the building on weekends. Lighting schedules differ during the year with minimum usage in summer and almost full usage on winter days.

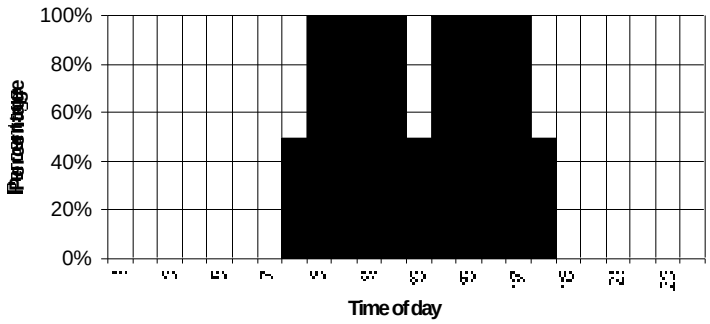

Figure 2. Schedule of occupancy of office areas

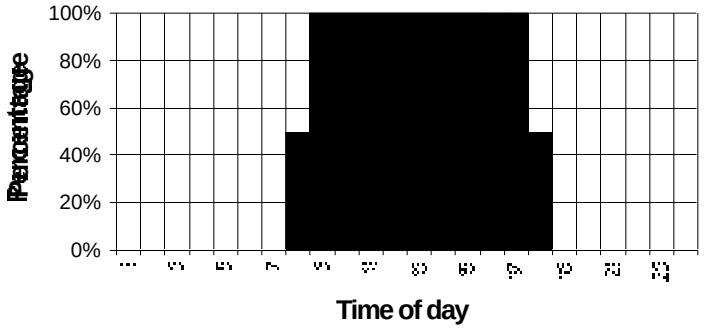

Figure 3. Schedule of use of equipment

Infiltration and Ventilation Strategy

Infiltration due to building fabric leakage was fixed at 0.3 ach for the 24 hour period. A minimum ventilation rate during occupied hours, year round, was taken at 1.14 ach in addition to the 0.3 ach leakage (see fig. 4). This made a total level of 1.44 ach, and includes the minimum level of fresh air supply per person.

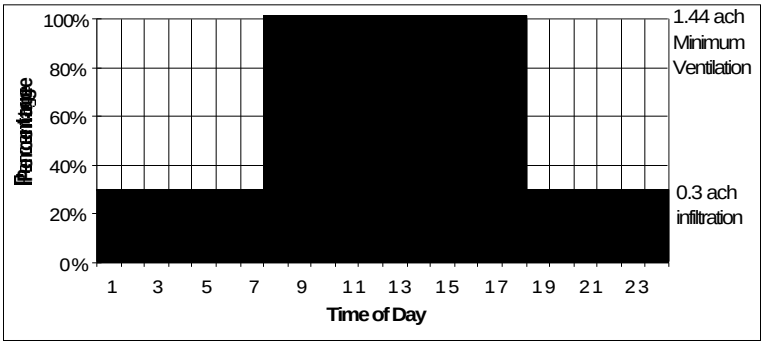

Figure 4. Minimum Ventilation rate (including infiltration)

A variable rate of ventilation was considered to operate as a consequence of the indoor air temperatures achieved only during the summer period (Warren & Parkins, 1984)[2]. The maximum ventilation rate assumed was 7 ach. This depended on the internal room air temperature. From a minimum level (see Figure. 4) this rate was increasing by 1.14 ach for each degree of indoor temperature above 21°C. Thus a total rate of 7 ach would be assumed at indoor temperatures of 25°C and above (see Figure. 5).

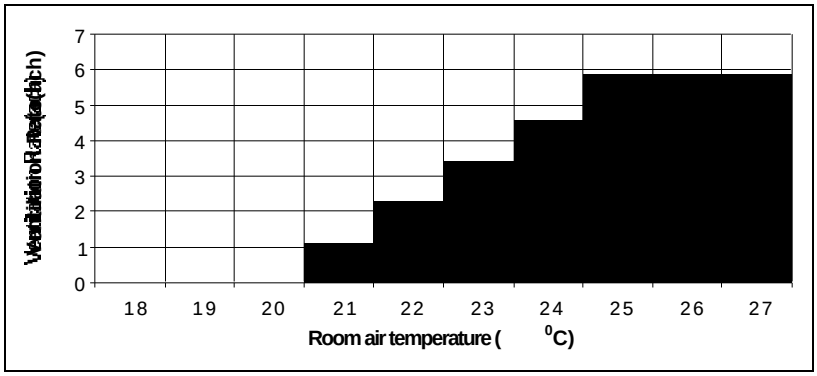

Figure 5. Maximum Ventilation rate

A night ventilation strategy was assumed to operate for the summer period. This would be achieved by opening windows or shutters behind louvres. In this case the equivalent ventilation rate was taken as 6 ach.

Internal shading (blinds).
All external window are considered equipped with internal, venetian blind style, shading or other devices (CIBSE)[3] for which the shading coefficient value is 0.61 and short-wave radiation fraction is 0.3 (see Annex).

All external rooflights are considered to be equipped with internal shading devices (such as Velux roller blinds) for which the shading coefficient value is 0.59 and short-wave radiation fraction is 0.3 (see Annex).

Internal shading devices are intended for operation during the occupied periods. They are assumed to be lowered when the incidental solar radiation is greater than 200 W/m_ and raised when the incidental solar radiation is lower than 100 W/m_ ,

External shading from obstructions such as trees and other buildings is considered to be present all year round.

Findings

Building Simulation Results

The simulation results are based on the predicted hourly mean internal air temperatures calculated using the building simulation program APACHE***/3TC*** (FACET)[4]. This thermal simulation software package provides a dynamic simulation based on building form, usage, and environmental services.

Thermal modelling was carried out for all 12 office units using appropriate hourly weather data, levels of internal gain, ventilation and infiltration losses. A night cooling strategy and the use of external and internal shading were also assumed. Results for all the cases studied are presented for each individual office unit.

The predicted internal air temperatures presented here indicate the percentage of occupied hours at 25°C or lower. The BCO recommends that internal comfort temperature should be at or below this level for 95% of the occupied time in naturally ventilated buildings.

In this case no additional cooling is required; each office unit can be naturally ventilated by opening windows. The predicted internal comfort conditions for all 12 office units are presented in Table 2.

Table 2. Summary results, including number and location of rooflights; predicted internal comfort conditions; and Average Daylight Factor, for all 12 office units.

	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G	Unit H	Unit I	Unit J	Unit K	Unit L
Roof lights No.	3	4	4	4	3	4	4	4	6	6	3	6
Location	North East Elevat.	North East Elevat.	North West Elevat.	North West Elevat.	South East Elevat.	South East Elevat.	South East Elevat.	South East Elevat.	South East Elevat.	East Elevat.	East Elevat.	East Elevat.
Pecentage of time at and below 25°C for the ground floor	95.0	96.6	96.1	95.9	97.2	98.0	98.0	98.0	98.0	97.7	97.8	96.1
Pecentage of time at and below 25°C for the first floor	95.2	95.6	95.4	95.2	96.7	96.4	96.4	96.4	96.1	95.6	96.1	95.4
Average pecentage of time at and below 25°C for office unit	95.1	96.1	95.8	95.6	97.0	97.2	97.2	97.2	97.1	96.7	96.9	95.8
Average Daylight Factor	4.3	4.5	4.8	5.1	4.1	4.3	4.4	4.3	3.7	4.2	4.8	5.4

Average Daylight Factor (ADF) calculations for all 12 office units were carried out using the CIBSE Method[5] with the aim of achieving predominantly daylit spaces. CIBSE recommends a 2% ADF for spaces that are partially daylit and a 5% ADF for spaces that are completely daylit (although in practice some electric lighting is almost always necessary).

The calculation results for ADF shown in Table 2 indicate that all but one of the ADFs was over 4% (the exception being only marginally lower at 3.7%), providing spaces which are predominantly daylit, with a limited need for electric lighting.

Conclusion and recommendations

Calculations of daylight and thermal comfort performance have been carried out for 12 naturally ventilated office units at Eastern Road in Bracknell. The calculations were based upon information supplied by the client (including building geometry, location, orientation, material properties and window sizes), and on assumptions which included BCO recommended parameters for the design of naturally ventilated office buildings (such as typical levels of internal gains, occupant density, minimum fresh air requirements). Occupancy and operating conditions were based on a typical 8.00 to 18.00 pattern of office use. Hot weather data records for Bracknell were used.

Results from the calculations were used first to determine the optimum location, orientation, size, and quantity of Velux rooflights, with the objective of ensuring that adequate levels of daylight would be obtained in all 12 office units. Dynamic thermal simulations were then performed to predict internal air temperatures for comfort conditions, and the percentage of occupied hours during which the air temperature would not exceed 25°C.

Results from the dynamic thermal simulations showed that all 12 offices units could achieve comfort temperatures below 25°C for 95% of the occupied time, corresponding to the BCO recommended criterion for avoiding overheating in naturally ventilated buildings.

The calculations of Average Daylight Factor (ADF) indicated that the spaces would be well daylit, according to the CIBSE criteria for partially daylit offices, significantly reducing the need for electric lighting.

References

1) British Council for Offices (1994). Specification for urban offices.

2)) Warren P.R and Parkins L.M. (1984) Window-opening behaviour in office buildings, Building Services Engineering Research and Technology. Vol. 5 No. 3.

3 Chartered Institute of Building Services Engineers (1986). CIBSE Guide. Volume A.

4) IES-FACET (1995) APACHE 7.5.8 User Manual (Applications Program for Air Conditioning and Heating Engineers)

5) Chartered Institute of Building Services Engineers (1994). CIBSE Code for Interior Lighting.

Annexes

Eastern Road , Bracknell:
Glass and blind properties for daylight and overheating calculation

	Windows	Roof lights	Shopfronts	Blind	Blind
	Velfac			Roller	Venetian
External Reflectance %	15	27	23.3		
Absolute transmission %	26	32	41		
Direct Transmission %	59	41	34.7		
Light Transmission	75	75	64.3		
U' Value	1.8	1.7	1.62		
Shading Coefficient				0.59	0.61
Short wave Radiation Fraction				0.3	0.3