APPENDIX B

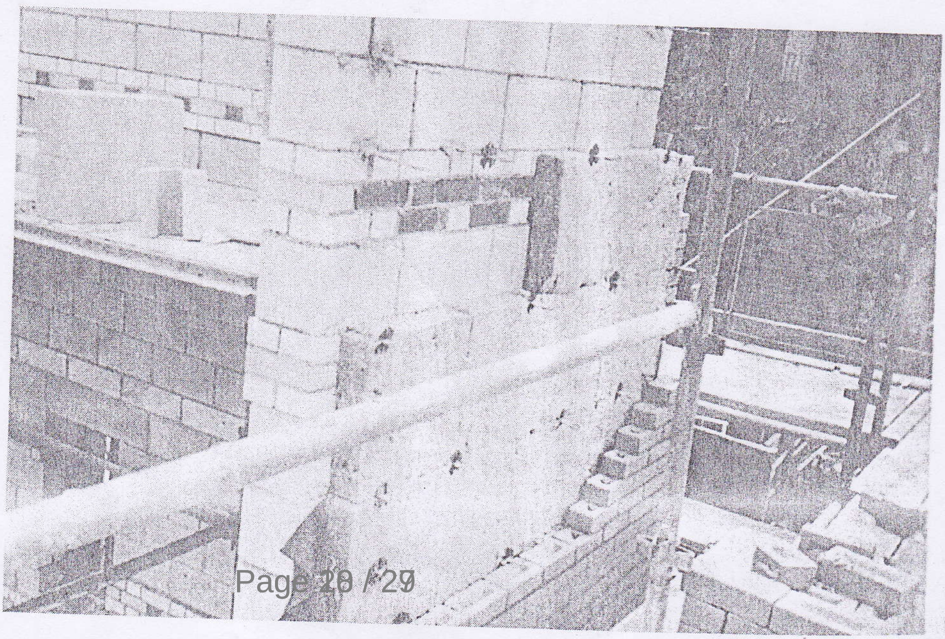
Calculation procedures

B.1 U-value calculations

The U-value is the rate of heat flow per unit area from the fluid (usually air) on the warm side of the element to the fluid (again usually air) on the cold side. The procedure for U-value calculations is given in numerous references[1,2,3] along with thermal conductivities for various materials. Values of thermal conductivity vary somewhat according to the reference consulted. Manufacturers will provide the most accurate test data for their products.

Here we shall simply give one example of a calculation of a wall at the De Montfort University Queens Building (Figure B.1; Chapter 13).

1. Construction
   - 190 mm dense concrete block (*NB* dense block was used because it is a load-bearing element in this four-storey all masonry construction building)
   - 100 mm Rockwool cavity batts
   - 100 mm brick (*NB* 100 mm is nominal and suitable for our purposes. The actual brick width is 102.5 mm).
2. Internal surface resistance: use 0.12 m^2 K/W
   External surface resistance: use 0.06 m^2 K/W.



B.1 The wall under construction.

3. Thermal conductivity:
   dense concrete block: 1.63 W/m K
   Rockwool: 0.035 W/m K
   brick: 0.84 W/m K.
4. To calculate the thermal resistance of a building element:

$$\text{Resistance}\ \frac{(\text{m}^2\ \text{K})}{\text{W}} = \frac{\text{Thickness (m)}}{\text{Conductivity (W/m K)}}$$

5. Add the resistances of all elements:
   Internal surface resistance = $0.12\ \text{m}^2\ \text{K/W}$

$$\text{Resistance of block} = \frac{0.19\ \text{m}}{1.63\ \text{W/m K}} = 0.12\ \text{m}^2\ \text{K/W}$$

$$\text{Resistance of Rockwool} = \frac{0.1\ \text{m}}{0.035\ \text{W/m K}} = 2.86\ \text{m}^2\ \text{K/W}$$

$$\text{Resistance of brick} = \frac{0.1025\ \text{m}}{0.84\ \text{W/m K}} = 0.12\ \text{m}^2\ \text{K/W}$$

External surface resistance = $0.06\ \text{m}^2\ \text{K/W}$

Sum of resistances = $3.28\ \text{m}^2\ \text{K/W}$

6. The U-value is the reciprocal of this:

$$\frac{1}{\text{Sum of resistances}} = \frac{1}{3.28\ \text{m}^2\ \text{K/W}} = 0.30\ \text{W/m}^2\ \text{K}$$

B.2 Daylighting calculations

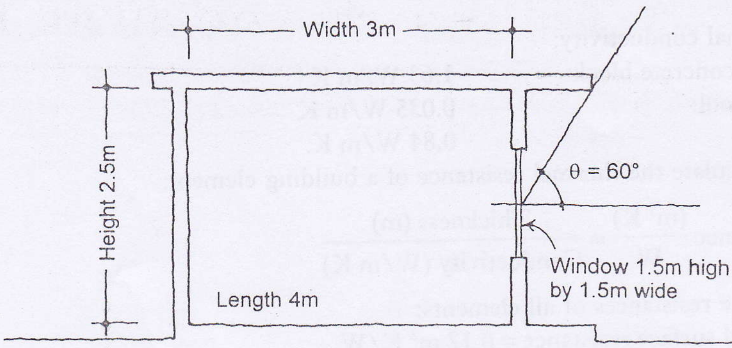
A number of references deal with estimating daylight in buildings and the calculation of the average daylight factor (ADF).[4,5] The ADF (Chapter 5) for a side-lit interior is given by

$$\text{ADF} = \frac{TA_w\theta}{A(1 - R^2)}$$

where T is the diffuse light transmittance of the glazing including the effects of dirt, blinds, obstructions and coverings; A_w is the window area (m^2); θ is the vertical angle subtended at the centre of the window by unobstructed sky; A is the total area of indoor surfaces (ceiling, walls and floor, including glazing); and R is the area-weighted average reflectance of ceilings, walls and windows. We can apply this to the very simple case shown in Figure B.2.

Let us assume that $T = 0.75$ and

Reflectance of the ceiling	= 0.7
Reflectance of the wall	= 0.5
Reflectance of the window	= 0.1
Reflectance of the floor	= 0.3



B.2 Daylighting for side-lit interiors.

The total area of the room is 59 m^2. The average reflectance is area weighted in the following way:

(R side wall) × (Area side wall)	= (0.5)(3)(2.5)	= 3.75
(R side wall) × (Area side wall)	= (0.5)(3)(2.5)	= 3.75
(R back wall) × (Area back wall)	= (0.5)(4)(2.5)	= 5.00
(R front wall) × (Area front wall)	= (0.5)(10 − 2.25)	= 3.88
(R window) × (Area window)	= (0.1)(2.25)	= 0.23
(R ceiling) × (Area ceiling)	= (0.7)(4)(3)	= 8.4
(R floor) × (Area floor)	= (0.3)(4)(3)	= 3.6
	Total	= 28.61

then,

$$R = \frac{28.61}{59} = 0.48$$

and

$$ADF = \frac{0.75(2.25)(60)}{59[1-(0.48)(0.48)]} = 2.2\%$$

Thus, in conditions of a standard overcast sky of 5000 lux, the average light level would be 5000 × 2.2% = 110 lux.

References

1. Anon. (1980) *CIBSE Guide A3: Thermal Properties of Building Structures*, CIBSE, London.
2. Burberry, R. (1992) *Environment and Services*, Longman, Harlow.
3. Littler, J.G.F. and Thomas, R.B. (1984) *Design with Energy*, Cambridge University Press, Cambridge.
4. Anon. (1994) CIBSE code for interior lighting. CIBSE, London.
5. Anon. (1986) Estimating daylight in buildings: Part 2. BRE Digest 310. BRE, Garston.