The Role of Ventilation
15th AIVC Conference, Buxton, Great Britain
27-30 September 1994

A Review of Weather Data for Natural Ventilation

M J M Arif, G L Levermore

UMIST, Building Engineering Dept

A review of weather data for natural ventilation

MJM Arif Building Eng Dept UMIST
GJ Levermore Building Eng Dept UMIST

Synopsis

This paper briefly reviews the weather data available for natural ventilation and briefly reviews hourly data for simulation. It starts by reviewing the need for basic data for initial manual calculations. It then discusses the hourly weather data available for example the UK CIBSE Example Weather Years, and the European Community Test Reference Years. These are mostly selected for energy analyses rather than design, but there is still a need for establishing general criteria for weather data for design of HVAC services and natural ventilation. The paper examines weather data for summer conditions and the need to consider solar radiation as well as outside/inside temperatures and wind speed and direction for natural ventilation. A simulation of a typical building is used to demonstrate the importance of solar radiation.

1. Introduction

Extensive effort has been made to reduce energy consumption in buildings through better design of services and building envelopes. In winter, designers are concerned about energy losses through the fabric and the effectiveness of the heating system to provide warmth. Whereas in summer designers make efforts to try to ensure that the cooling system will consume minimal energy whilst maintaining comfort.

One use of energy that has been of arguable concern has been the use of air conditioning in the United Kingdom. It has been proposed that natural ventilation may alone be adequate. However, as this paper discusses, solar gain is a major heat gain after equipment gains in modern offices. So the designer of the natural ventilation system must be aware not only of wind data, and indoor-outdoor temperature differences for stack ventilation but coincident solar radiation must also be considered.

2. Weather Data

It is well understood that the prime agencies for natural ventilation and infiltration are the wind velocity and the stack effect depending on the difference between internal and external air temperatures. In principle the air flow through a building and the ventilation rates of individual spaces within a building can be determined for a given set of weather conditions. However, due to a number of flow paths likely to be present, the calculation can be very complex.

As to the weather data there are a number of sources in the UK including the Meteorological Office and the CIBSE Guide Section A2(1). However, computer simulation is becoming increasingly important in design and Section A2 is primarily for manual design. Example weather years exist for energy analyses, but not design. CIBSE has its Example Weather Years(2,3) for simulation for energy analysis. There are other sources of weather data for energy simulation,(4), as well as the EC's Test Reference Years(5) and ETSU's data(6). Recently a committee of the IEA has developed a further selection method for Designing Reference Years (DRY) but this is oriented mainly towards modelling active solar systems(11). As yet there is no concensus on the period or the extreme values of weather data for the design of naturally ventilated buildings by simulation,(or for mechanically ventilated or air conditioned buildings), although the ETSU EWY work additionally identified three types of "design day"(8). Recently CEN Working Groups have been set up to consider selection methods for sequences of extreme hot, sultry weather for both naturally ventilated and air-coditioned buildings. However, selection criteria are now being discussed in the Wind Data Task Group of CIBSE which is helping rewrite Section A2 as a seperate volume J of the CIBSE Guide. Initial ideas on selection centre on the need for data on coincident wind velocity, direction and the coincident inside/outside temperature difference. But to promote further discussion this paper considers that coincident solar radiation is also an important parameter.

To examine some of these weather parameters the CIBSE Example Weather Year for Kew 1964-65(7), has been analysed. Summer conditions, when natural ventilation will be tested most, have been considered primarily. Fig. 1 shows that in the summer,(taken as June,July and August), the horizontal direct solar radiation generally increases as the outside temperature increases. But Fig. 2 indicates that high wind speeds and high solar radiation do not necessarily tend to coincide. Perhaps this is due to high solar radiation usually occuring in the UK during periods of high atmospheric pressure(anticyclones) when the wind is also generally calm. This does not help natural ventilation. Also the wind speed tends to be lower in the higher temperature periods of the summer as Fig.5 shows.

3. Building Simulation

For this paper the FACET Apache program has been used for the building simulation. In order to illustrate all the varying factors on a consistent basis, a 'typical' commercial building geometry, developed by BRE is used as a reference building(8). Its dimensions are 12.0m length, 5.5m width and 2.65m height.

For this simulation a brick faced wall was choosen with a flat roof and both are insulated to 1990 Building Regulation Standards. The orientation of the building is with the long walls facing north and south. Only the long walls were glazed.
One of the three storeys was considered in the simulation. Results are shown for a 'worst case' day in July.

3.1 Effect of Air Changes

Wind speed and stack effect can affect the rate of air changes in a building. It is important to know how much the rates of air change affect the internal air temperature of the building.
By simulating the sample building with 35% glazing, as in Fig. 3, it is shown that higher rates of air changes can reduce its internal air temperature, with significant improvement from 1 ach(air changes per hour) to 10 ach, after which further increases of air changes do not improve the situation very much. The CIBSE Guide(9) gives an empirical average value of 3 ach in Table A8.4 for the normal case of windows open in daytime and closed at night, and a value of 10 ach if the windows are open day and night. Warren and Parkins(10) suggest air change rates of up to 8.8 ach in warm weather with ventilation on one side only when windows are open. It is known that ventilation rates vary considerably under the influence of wind, user operation of blinds and windows, stack effect, etc. but the variations very much depend on the circumstances. With the windows closed the rate could be very low(less than .25 ach) but with cross-ventilation it could be as high as 24 ach(10). Fig. 6 also demonstrates that the pattern of ventilation can lower the internal temperature of the building. For instance allowing ventilation 2 hours earlier in the morning or overnight at 25% of the daytime rate in addition to daytime ventilation, lowers the temperature slightly.

3.2 Effect of Solar Radiation

Solar radiation is often a major source of heat gains in buildings during the summer season, by direct radiation into the room and by conduction through the fabric and windows. Reducing the amount of glazing area and provide shading from direct radiation are the best ways to minimise these gains.

In Fig. 4, the sample building is simulated to have different amounts of glazing from 1% to 100% areas of the long walls. It is found that as the percentage of glazing reduces so the inside temperature reduces. However, even the lowest peak temperature is still high and in practice the solar gains could be reduced by using blinds on the windows.

3.3 Glazing and Air Changes

In Fig.3 and Fig.4 the sample building is simulated with 25% glazing and 10 ach(100% daytime and 25% overnight). It shows that this combination is better than the highest ACH at 35% glazing and as good as 5% glazing at 10 ACH. A summary of these combined effects is plotted in Fig. 7, showing that the rate of air changes is of diminishing effect with increasing air change rates.

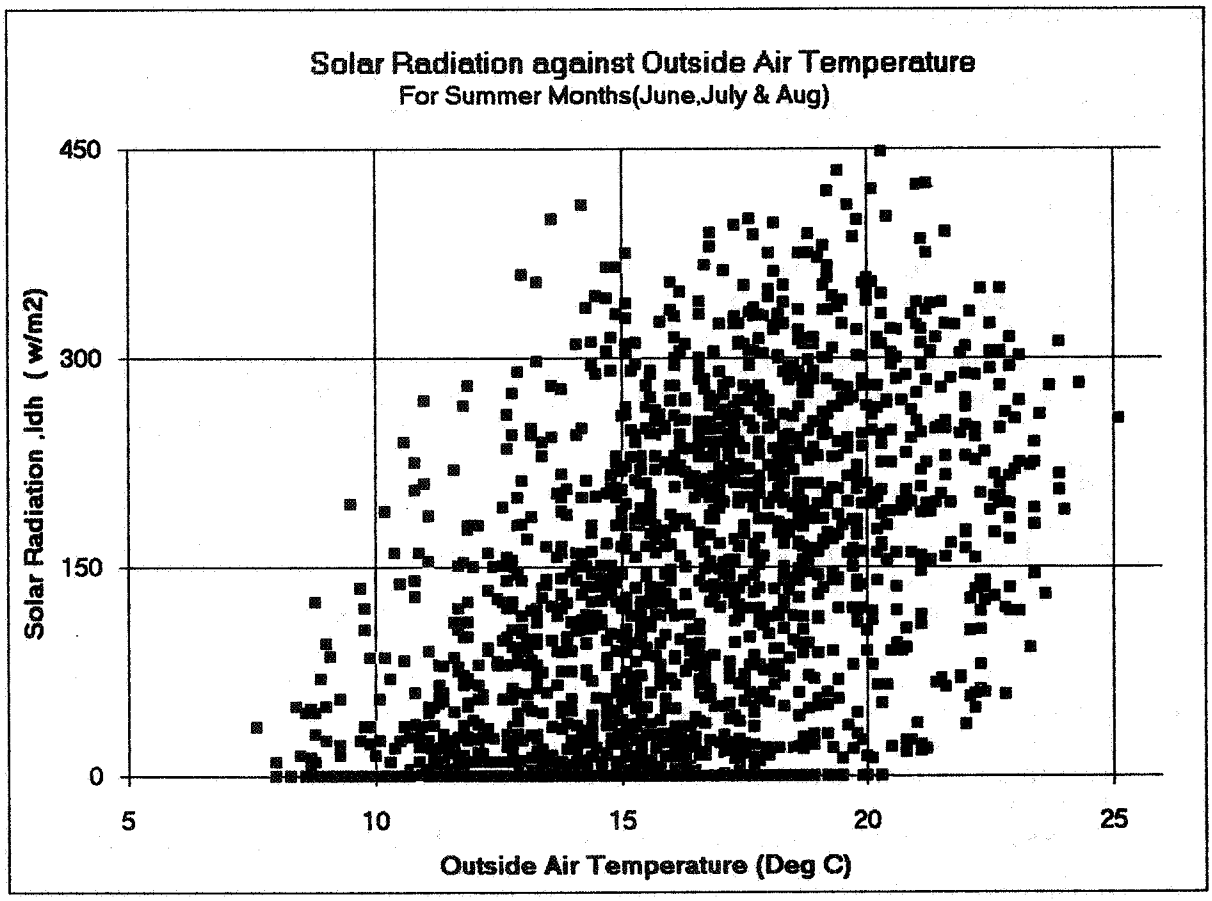
Reducing the amount of glazing is the most significant contribution in reducing the inside air temperature. Further reduction in solar radiation is expected when external shadings and blinds are used.

4. Conclusion

This paper shows that coincident solar radiation should be considered when weather data is selected for use in the design of naturally ventilated buildings.

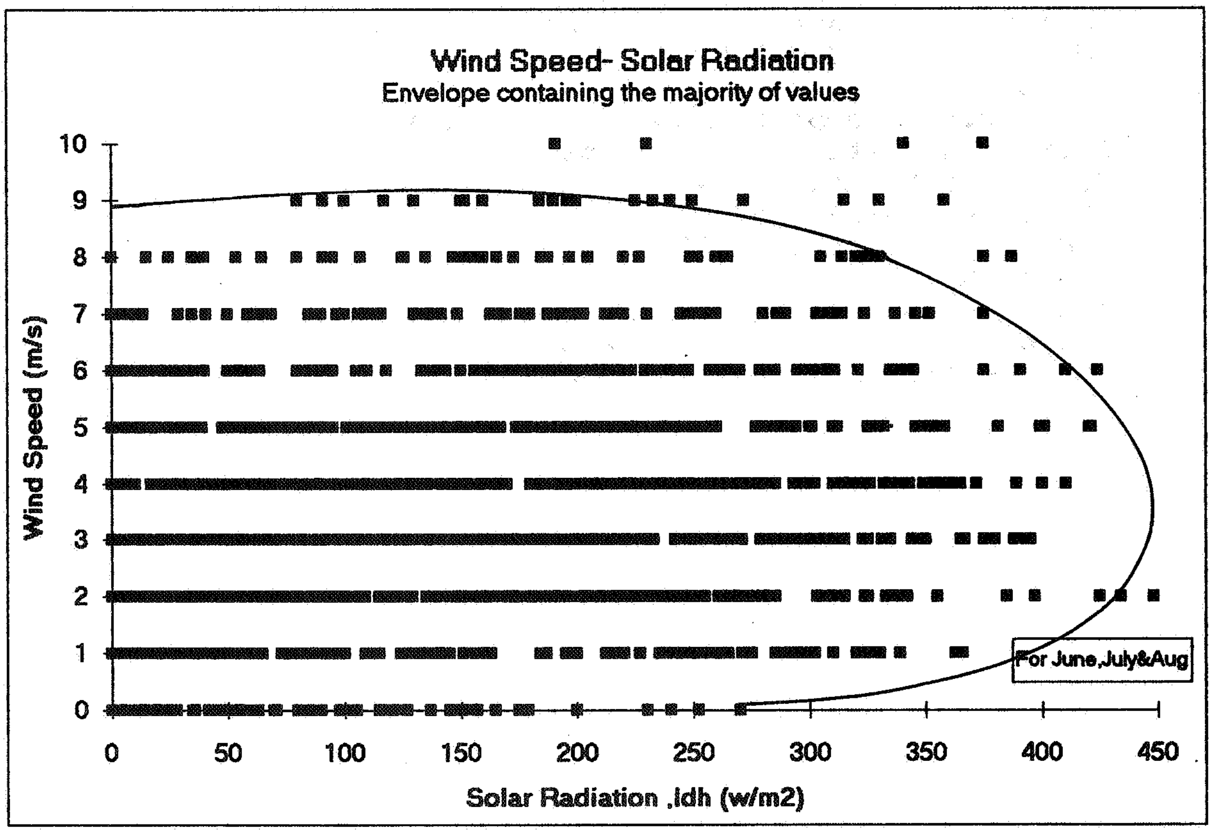
References

1. CIBSE Guide Volume A, Section A2
"Weather and Solar Data", CIBSE 1986
2. Holmes,M.J, Hitchin, E.R.
"An Example Year For Calc'ting Energy Demand In Buildings"
Building Services Engineer, 45,1978, pp 186-9.
3. Hitchin, E.R, Holmes, M.J, Hutt B.C, Irving, S.& Nevrala,D.
"The CIBSE Example Weather Year"
BSER & T, 4(3),1983, pp 199-24.
4. Keeble, E.J.
"Availability of weather data for use in simulation"
BEPAC Technical Note 90/1
Building Environmental Performance Analysis Club,1990
5. Lund, H.
"Test Reference years,Try: Data on magnetic tape for 29 Meteorological Stations in European Community"
Thermal Insulation Laboratory(Handbook),
Technical University of Denmark,for CEC,1984
6. Akehurst, P.
"Passive solar design studies: Provision of weather data"
FACET Ltd, St Albans, for ETSI, 1990
7. Letherman, K.M. and Wai, F.M.
"Condensed Statistics on the CIBS Example Year-Kew"
BSER & T,1980,(1),pp 157-159; BSER & T, 1981, 2, pp 165-173.
8. Leighton, D.J and Pinney, A.A.
"A set of Standard Office Description for Use in Modelling Studies" BEPAC TN 90/50
9. CIBSE Guide Volume A, Section A8
"Summertime Temperatures in Buildings"
Chartered Institute of Building Services, 1986.
10. Warren, P.R. and Parkins, L.M.
"Window-opening behaviour in office buildings"
BSER & T, Vol 5(3), 1984, pp 89.
11. Lundh, H.
"The Design Reference Year"
Building Simulation 1991, Proc IBPSA Conference,
Sophia-Antipolis/Nice, 1992-08-20/22, pp 600-606



Solar Radiation against Outside Air Temperature
For Summer Months(June,July & Aug)
450
300
150
0
5
10
15
20
25
Solar Radiation ,Idh (w/m2)
Outside Air Temperature (Deg C)

Fig. 1



Wind Speed- Solar Radiation
Envelope containing the majority of values
10
9
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
300
350
400
450
Wind Speed (m/s)
Solar Radiation ,Idh (w/m2)
For June,July&Aug

Fig. 2

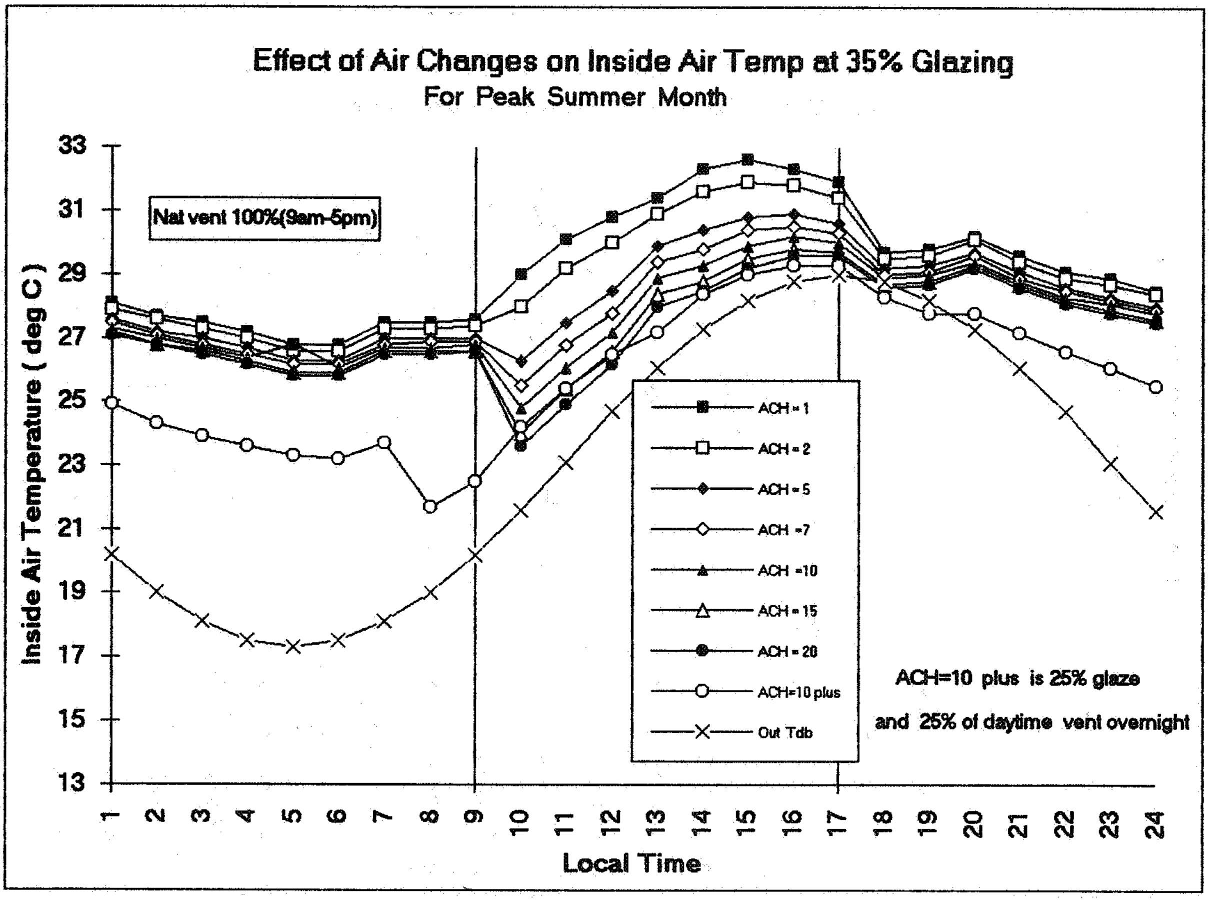

Effect of Air Changes on Inside Air Temp at 35% Glazing
For Peak Summer Month
Inside Air Temperature (deg C)
Nat vent 100%(9am-5pm)
ACH = 1
ACH = 2
ACH = 5
ACH =7
ACH =10
ACH = 15
ACH = 20
ACH=10 plus
Out Tdb
ACH=10 plus is 25% glaze
and 25% of daytime vent overnight
Local Time

Fig. 3

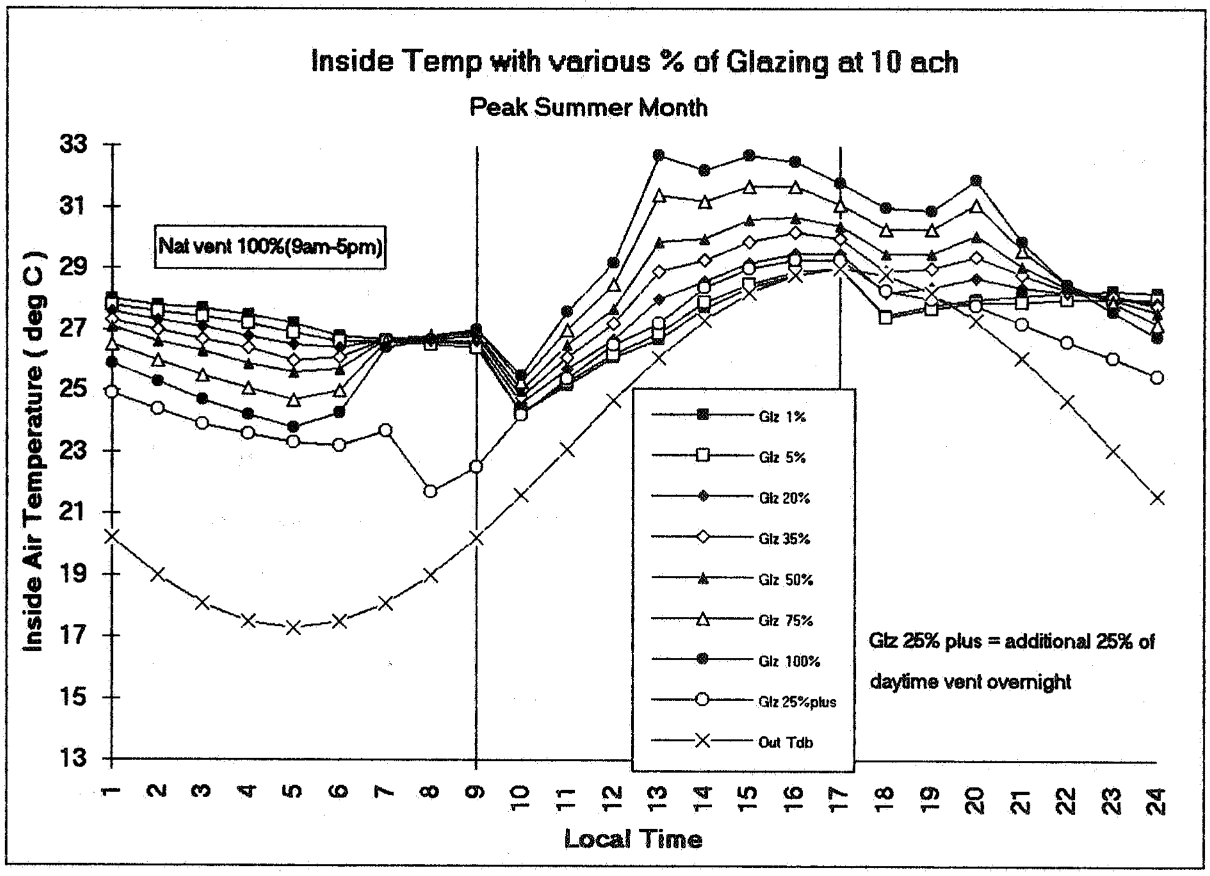
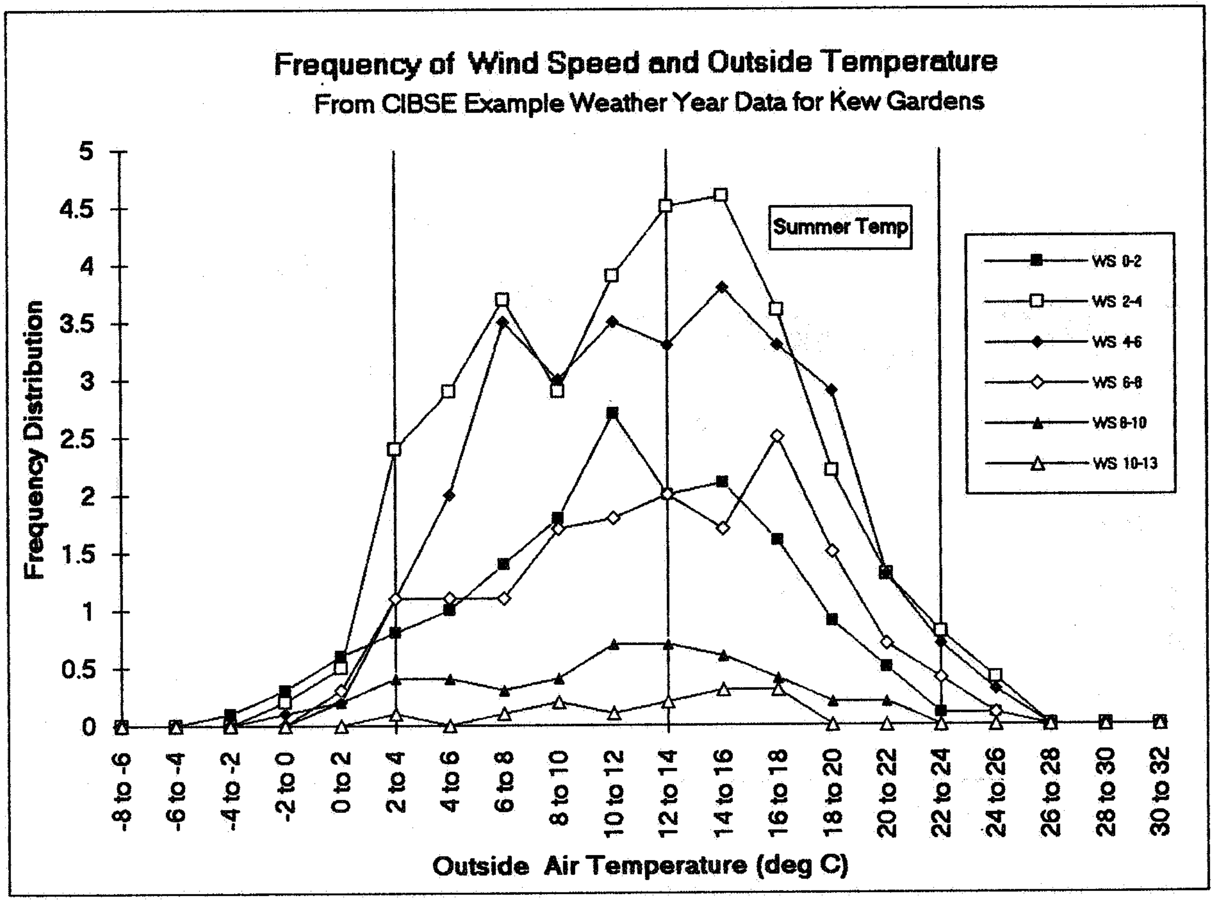
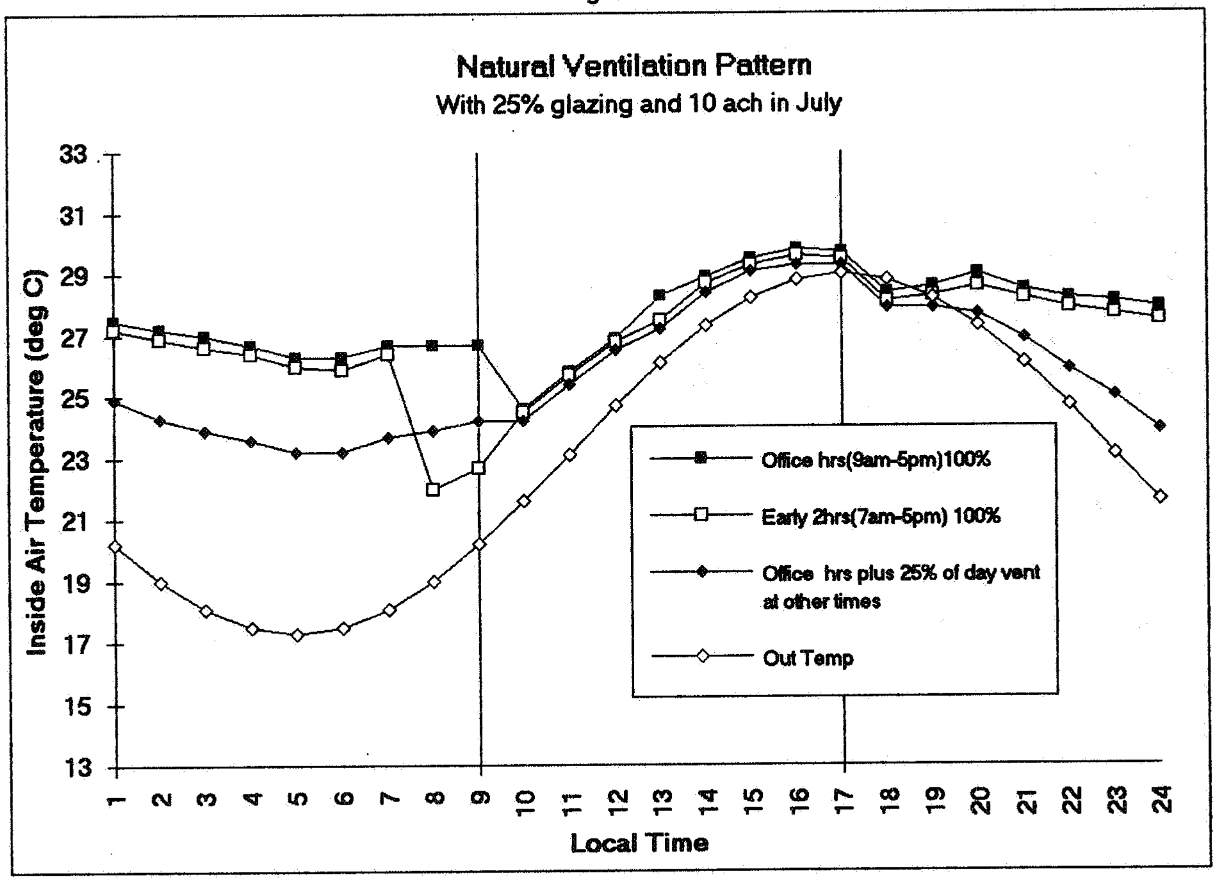

Inside Temp with various % of Glazing at 10 ach
Peak Summer Month
Inside Air Temperature (deg C)
Nat vent 100%(9am-5pm)
Glz 1%
Glz 5%
Glz 20%
Glz 35%
Glz 50%
Glz 75%
Glz 100%
Glz 25%plus
Out Tdb
Glz 25% plus = additional 25% of
daytime vent overnight
Local Time

Fig. 4



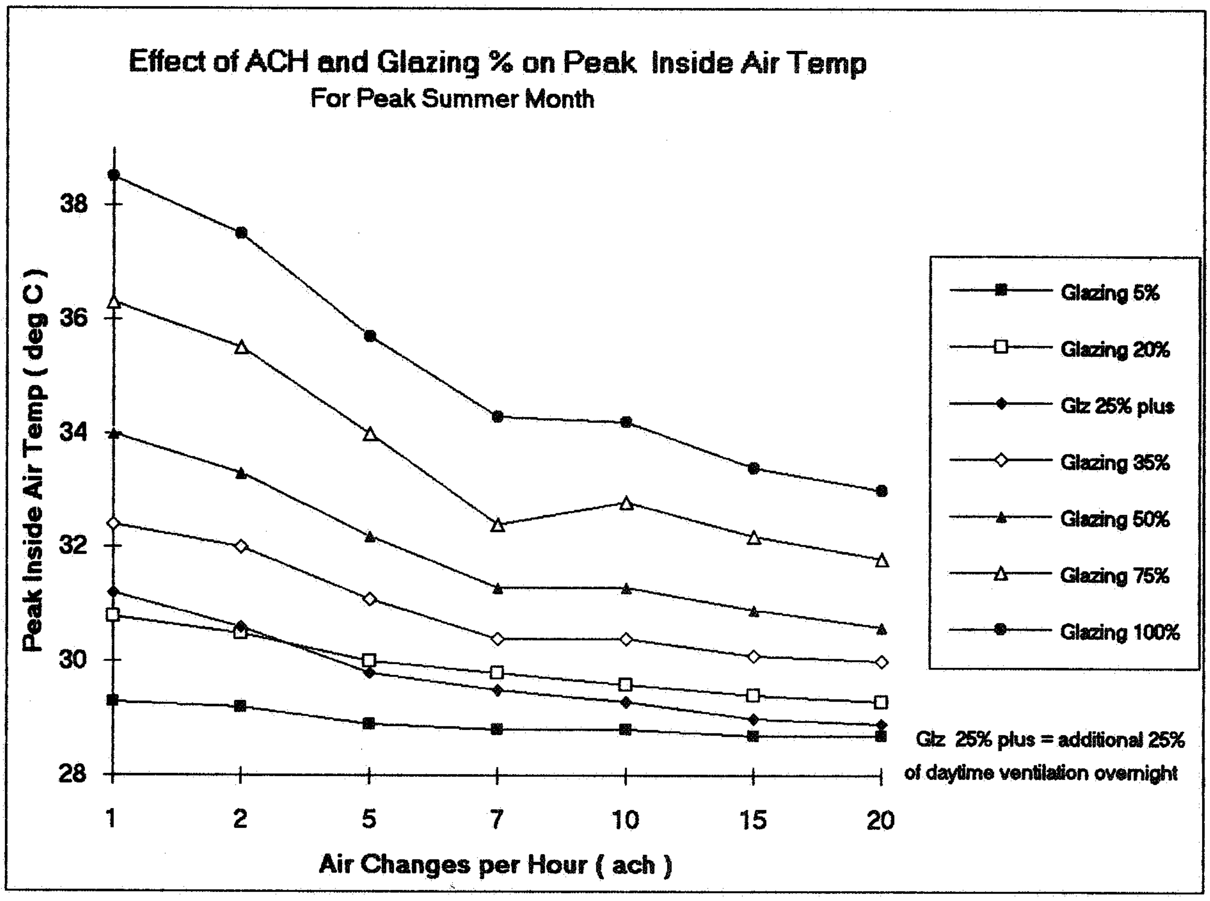
Frequency of Wind Speed and Outside Temperature
From CIBSE Example Weather Year Data for Kew Gardens
Frequency Distribution
Summer Temp
WS 0-2
WS 2-4
WS 4-6
WS 6-8
WS 8-10
WS 10-13
Outside Air Temperature (deg C)

Fig. 5



Natural Ventilation Pattern
With 25% glazing and 10 ach in July
Inside Air Temperature (deg C)
Office hrs(9am-5pm)100%
Early 2hrs(7am-5pm) 100%
Office hrs plus 25% of day vent at other times
Out Temp
Local Time

Fig. 6



Effect of ACH and Glazing % on Peak Inside Air Temp
For Peak Summer Month
Peak Inside Air Temp (deg C)
38
36
34
32
30
28
1
2
5
7
10
15
20
Air Changes per Hour (ach)
Glazing 5%
Glazing 20%
Glz 25% plus
Glazing 35%
Glazing 50%
Glazing 75%
Glazing 100%
Glz 25% plus = additional 25%
of daytime ventilation overnight

Fig. 7