WEATHER PERFORMANCE AND THE COMFORT ZONE.

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SUMMARY

Weather data has been regularly collected from a computer based weather station at CSIRO, North Ryde. A brief analysis performed on some of the data, pertaining to the comfort zone, is reported here

INTRODUCTION

The external weather has a significant impact on the building and directly controls the comfort and behaviour of the building's occupants. There are well established guidelines for the optimum temperature and relative humidity in an office environment thus defining the comfort zone for the occupants. It is assumed that people working in this environment will be able to achieve increased productivity compared to others working in an inferior environment. Therefore, any additional costs involved in maintaining the optimum environment will be balanced by the increased productivity.

However, achieving the appropriate comfort zone in a building is quite a complex challenge. The parameters of the comfort zone are controllable by mechanical devices (eg. air conditioning units). Early in the design stages, within reasonable accuracy, it is possible to estimate the load placed on the air conditioning units on the basis of the type of accommodation, space available and any equipment likely to be present.

Normally, the air conditioning units operate on 15% fresh-85% re-circulation basis (although special buildings such as hospitals have their own rates). Therefore, any change in the external weather pattern will influence the conditions inside the building. An understanding of the external weather pattern round the year and the rates of change of various parameters will be necessary to successfully design an efficient air conditioning unit.

To understand the effect of external weather on various aspects of building design and its life cycle, a computer based weather station was established at DBCE, CSIRO at North Ryde. A full description of the facility is provided by Sankaran and Paterson (1995). A wide variety of atmospheric weather data are regularly collected and stored for analysis. In this paper, a brief analysis of the weather data pertaining to human comfort zone is provided. Due to limited space only typical examples are discussed here and a full length paper will be published else where.

COMFORT ZONE AT WORK

The core body temperature of a human being is $37^{\circ}C \pm 1^{\circ}C$ and the skin temperature is about $33\text{-}34^{\circ}C$. The core temperature must be maintained to ensure body and brain functions.

Fundamentally, the interior conditions can be classified into 3 zones. These are cold, hot or comfortable. In the cold zone the conditions are inadequate to keep the body at the desired temperature and shivering can occur. The hot zone is, naturally, where the interior conditions exceed those that are necessary to maintain the body's core temperature. Heat stroke occurs at

40° C. The comfort zone is where adequate temperature and relative humidity are maintained so that a human being can work without discomfort.

A survey conducted in Sydney by Hindmarsh and MacPherson (1962) indicated that people are most comfortable to work at a mean temperature of 22°C ± 2°C. No discomfort or evaporation of water from the skin (sweating) occurs without noticeable wetting of the skin at these temperatures. This was also supported by the recommendations of American Society of Heating, Refrigeration and Air Conditioning (ASHRAE) and the Kansas State. A chart was produced which recommends a relative temperature of 25° C and a relative humidity of 40-50% as the main parameters of a comfort zone. Naturally these conditions are influenced by many factors such as age, fitness, workload and quite importantly air movement. It is recommended to have an air movement of approximately 0.22m/s.

There other indices that could be taken into account are: Body Core Temperature, Heat Rate, Predicted Four Hour Sweat rate, and Belding-Hatch heat stress index.

SPEED AND AFFECT OF RAPID ATMOSPHERIC CHANGES

When the external weather conditions change then the air conditioning system changes to suit. If the change is gradual then the system should have little or no difficulty in adjusting to keep up the optimum comfort zone. However, when the external climatic conditions change rapidly the air conditioning plant may not be able to keep up with the change and alter the indoor air temperature and humidity. Further, the changing conditions of the solid building surfaces (eg. glass) will also add additional complications. In any case, there is a likely period of uncomfortable working condition which may ultimately lead to the possibility of the system overloading and shutting down.

From the above discussions, it is clear that a good understanding of local climatic conditions and the rates of change of various parameters will not only enable to choose the appropriate mechanical air conditioning system but also will enable to control the interior paramters. In the following section, an analysis of data of temperature and relative humidity are presented. The main focus of the analysis is to see and identify the relationship between the various paramters which could be exploited to effectively control the interior conditions.

DATA ANALYSIS

The data was analysed to identify occurrence of rapid changes in the weather conditions. The collected weather data was split into two main categories: data during rainfall and data in the absence of rainfall. Then the collected date was broken down to weekly data and the variation of temperature and relative humidity over time were produced.

NO RAIN DATA

Figure 1 shows the variation of wind speed, atmospheric temperature and relative humidity for the month of January 1994. It can be seen, in general, as the temperature increased, the humidity decreased. Looking at the wind speed and temperature, it can also be observed that there is a reasonable similarity between the two.

The variation of relative humidity is significant on the 17/1/94 and its hourly variation is shown in Figure 2 for a period of 10 hours since the start of the drop and then rise of humidity. The slope of the graph for the humidity rise is 18.3 % RH per hour. The temperature drop is 6.5°C per hour for 2 hours. During this time period, there is little variation in the wind speed. January in Sydney is summer and therefore, the temperature setting for the air conditioning is probably 24° C. The outside air temperature has risen some 9° C over about 6 hours and the temperature of the building facade would have increased at a much higher rate. It is interesting to note that the atmospheric temperature has returned to its original value of about $20^{\circ}C$ within 2 hours. If this pattern is regular and repetitive, then it could be exploited to control the a/c unit characteristics to maintain the comfort zone of the working environment.

Comments attributed to Figure 1 can also be made to Figure 3. In particular, the sharp variation in the relative humidity (from about 95% to 30%) induces a significant increase in temperature over a short time. Much more data has to be analysed before any specific conclusions can be drawn.

RAIN DATA

Data similar to those that are presented in Figures 1 and 2 but during rainfall is presented in Figures 4 and 5. The plotted data is during a rain shower in the month of March 1994. It is interesting to note that there is a small variation in the relative humidity and temperature just before the start of the rainfall. As the rain shower commences, the relative humidity rises there is a very sudden but definite drop in its value before it rises again. A corresponding increase in temperature occurs to match the movement in humidity. (There is an asterisk on the graph to indicate where the rain started).

To look at one of these variations in more detail, the period from 16:00 hrs to 23:00 hrs on the 23/3/1994 is reproduced in figure 5. The dip in the relative humidity at the commencement of the rain showers and the corresponding rise in temperature are clearly noticeable. Similar patterns are observed during several other rain showers but these are not presented here due to lack of space. It is possible that this feature in the atmospheric weather can be utilised to control the interior climatic parameters.

CONCLUDING REMARKS

An understanding of the micro climate conditions will enable to appropriately design the air conditioning unit of buildings. This understanding can also help to maintain a constant interior comfort zone while the atmospheric conditions change quite rapidly. A simple analysis of weather data has been presented under the conditions of rain and no rain. It is possible that some patterns observed in relative humidity and temperature could be used to control and regulate the comfort zone within a building. However, more data has to be analysed before definite conclusions can be drawn.

REFERENCES

Hindmarsh, M.E. and MacPherson, R.K. (1962) Australian Journal of Science, V23, P335.
Sankaran, R. and Paterson, D.A. (1995) Proceedings of 9 ICWE, New Delhi.
Thermal Comfort at Work. Commonwealth Dept of Science and Technology, 1981, P37.

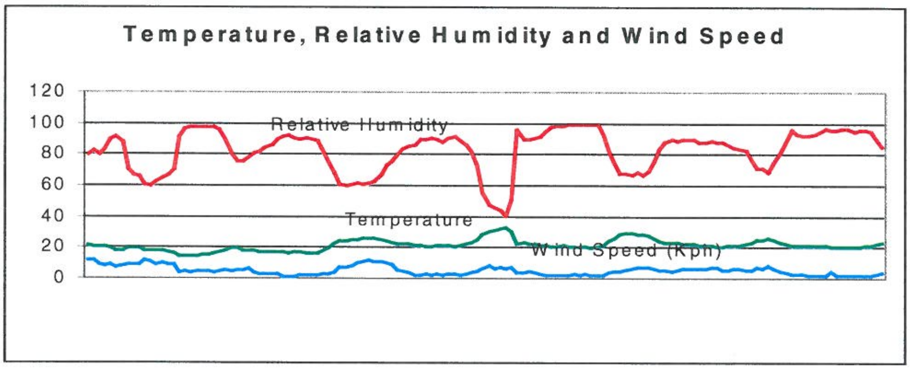

Figure 1 Variation of various weather parameters in January in Sydney, Australia..

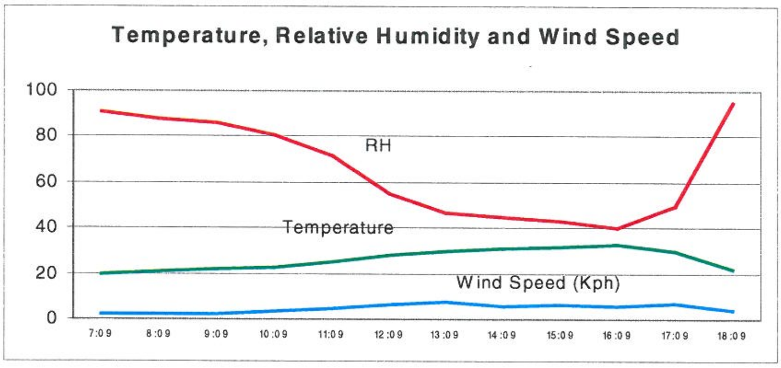

Figure 2 Variation of temperature and humidity on 17/01/1994

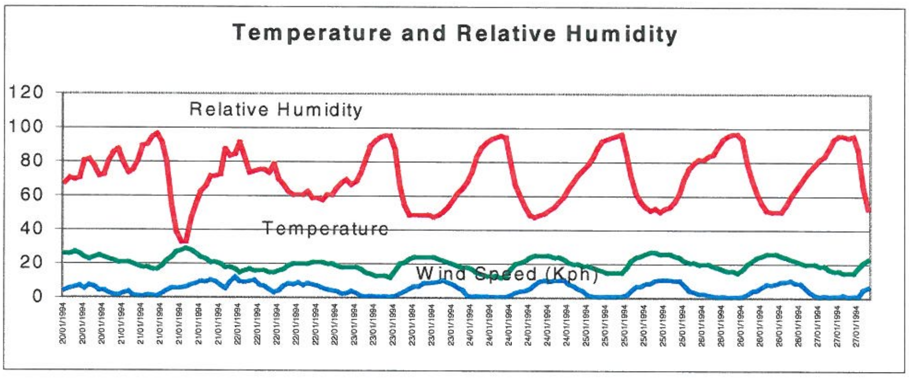

Figure 3 Variation of temperature and humidity in March 1994

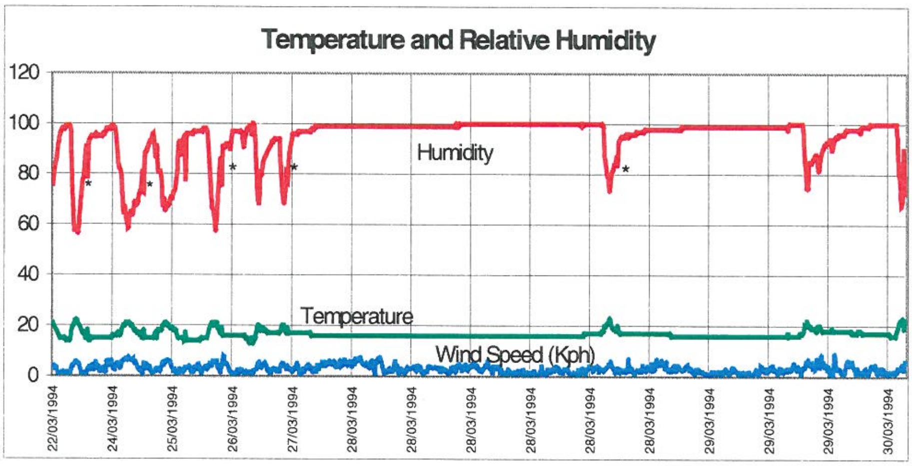

Figure 4. Variation of temperature and humidity in a rain period in March 1994

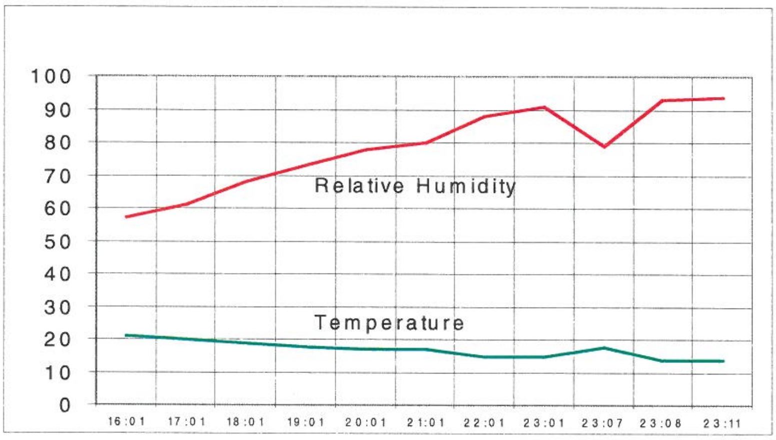

Figure 5 A close-up of relative humidity and temperature variation from figure 4