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VENTILATION ASPECTS OF MOISTURE IN BUILDINGS: A REVIEW AND ASSESSMENT OF THE FUTURE ROLE OF PREDICTION TECHNIQUES

1. Introduction

Moisture is a widespread problem affecting buildings in many climatic zones. The most noticeable ways in which this difficulty manifests itself are in terms of mould growth on walls and furnishings and as surface condensation. It may also contribute to poor health. Moisture is generated in buildings as part of the metabolic process of occupants and as a consequence of normal day-to-day activities such as cooking, heating and washing. It is variously estimated that, for normal household activities, between approximately 7 and 14 Kg of moisture may be generated within the home each day[1]. In addition, this total can be considerably increased by the use of unvented oil heaters and gas cookers and by indoor clothes drying. If not adequately controlled, the capacity of the air within the building to accommodate water vapour will eventually be exceeded, at which point condensation will occur. This problem is most likely to be apparent in the immediate vicinity of cold surfaces such as single glazed windows, thermal bridges and areas of poor thermal insulation. A potentially much more serious problem is for moisture-laden warm air to pass through adventitious openings in the envelope of the building and to condense, on cooling, within the building fabric. This form of condensation is most serious and can result in severe structural damage.

In addition to the moisture input generated by activities taking place within the building, the possibility of condensation occurring is very much related to both internal air temperature and the rate of air removal by ventilation. Since both of these factors have a direct impact on space heating needs, the control of moisture is of the utmost significance in building energy conservation design.

The objective of this report is to outline some of the principles behind air driven aspects of moisutre in buildings and to illustrate how calculation methods and mathematical modelling techniques may be used to both predict and remedy associated problems.

shows that ventilation requirements are dependent on the pattern of building use. A further problem is that, to maintain the same relative humidity for even a modest fall in air temperature, the ventilation rate would have to be much increased. In "wet" climates, for example, the ventilation rate would have to be doubled to maintain a 60% relative humidity at 17°C.

3. Minimising Moisture Risks

It is unlikely to be possible to control the risk of condensation by concentrating effort solely on any single contributory factor. It is more probable that a balanced approach to the problem involving a combination of measures will yield more successful results. Primary remedies should include a reduction in the generation of moisture, ensuring thermal integrity of the building and providing adequate ventilation. The use of dehumidification may also have an important role to play[3].

The control of moisture generation is largely in the hands of the occupant. It is clear from Figure 3 that the designer's task in anticipating the requirements of the occupant is formidable and it is questionable that an energy efficient approach could be achieved it if became necessary to accommodate the worst possible scenarios of occupant abuse. Education and perhaps statutory limitations on the availability of unvented appliances may prove to be a more successful route.

The thermal integrity of the building covers not only the need to maintain a sufficiently high enough temperature to avoid condensation but also the need to ensure that there are no cold spots which may depress temperatures sufficiently to cause severe localised problems. Undoubtedly some compromise is necessary since space heating is costly and therefore may not prove an attractive option to the occupier. The solution primarily rests with good building design and construction.

Ventilation approach also needs to be planned with care. To avoid the risk of condensation, moist air needs to be extracted from the building before problems arise. Most importantly, generated moisture should be extracted at source by the appropriate use of vents and exhaust terminals. Provision also needs to be made for adequate ventilation.

2. Background

Water vapour is invariably present as a constituent of the atmosphere. The amount present may vary considerably and is primarily dependent on geographic location and on variations in climatic parameters. The moisture content of air may be expressed in absolute terms either in the form of mass per unit mass of dry air (specific humidity) or as a partial pressure (vapour pressure). The amount of moisture that may be held within the atmosphere in vapour form increases as a function of both atmospheric pressure and air temperature. For a given atmospheric pressure, the percentage ratio between the actual vapour pressure of air at a given temperature and the maximum possible (saturated) vapour pressure at the same temperature is defined as the relative humidity. Should the moisture content of air increase, or the temperature of moist air reduce, to the point where a relative humidity of 100% is attained (dew point temperature) then condensation will occur.

Since cold air has a much lower capacity for holding moisture in vapour form than warm air (Figure 1), condensation is more likely to occur at depressed room temperatures. For a similar reason, climatic differences also impart important regional differences to the problem. Atmospheric air in extremely cold climates, for example, has a much lower water content for a given relative humidity than does air in much milder climatic regions. This is illustrated in Figure 2, where the average moisture content of outside air throughout the winter months for locations in Canada, New Zealand and the United Kingdom is illustrated. This shows that the average mid-winter water content of the atmosphere in Southern England is approximately 3.5 times greater than that in Ottawa, Canada, while in New Zealand the water content can exceed the Canadian value by a factor of almost 5. Thus for a given rate of moisture generation within a building, a much higher rate of ventilation will be necessary to dilute moisture in some regions than in others. Using data and calculation guidelines published in British Standard 5925[2], typical ventilation rates necessary to avoid the internal relative humidity exceeding 60% at 20°C in a 250 m^3 single family dwelling is illustrated in Figure 3. The data are presented for several sources of pollution and compare requirements for both a dry climate and a wet climate. The figure also highlights the relative significance of common moisture sources and, in particular, In mild climates, air infiltration coupled with window opening tends to provide the main source of fresh air, particularly in dwellings. Specific problems associated with this approach include wide variations in air change rates and haphazard air flow patterns. The latter problem, most especially, can give rise to moisture problems, although overall ventilation rates may be regarded as sufficient. In countries subjected to severe climatic conditions, buildings are necessarily much tighter and ventilation needs are increasingly being met by mechanical means. In such areas, this approach has proved extremely popular, since nowadays it almost always provides for heat recovery with the result that the additional capital cost of mechanical ventilation can often be quickly recovered. As a further advantage, mechanical ventilation can be used to achieve an optimum air distribution pattern for improved moisture control. However, in milder regions, the potential for cost effective heat recovery is extremely limited and thus this solution to the moisture problem is unlikely to be introduced to any significant extent in the forseeable future. It is therefore essential to re-examine current ventilation approaches and to develop solutions that are both appropriate and acceptable to the requirements of the occupant.

4. Calculation Techniques in Design

Recent advances in both experimental techniques and mathematical modelling approaches have resulted in a considerable improvement in the understanding of air distribution and air renewal in buildings. By combining the results of many measurements, it has become possible to verify the performance of numerical models and to develop very powerful predictive methods. It is these methods, in conjunction with experimental support, that should now be focussed on the problem of moisture control. In particular air flow models can be expected to give basic predictions on weather-related air flow and air change patterns. Thus they offer an inexpensive method for assessing design ideas at an early stage of development. From such work, the necessary guidelines for ventilation control of moisture may evolve. At a more complex level, combined dynamic heat loss and ventilation models, which may be used to predict condensation directly, are also becoming available[4]. While it can be expected that such models will remain exclusively in the research sector for some time to come, their application may still be expected to make an important contribution to the understanding and prevention of moisture problems.

The IEA's Air Infiltration Centre has for a number of years been involved in analysing the performance of infiltration and ventilation models. One of its current tasks has been the compilation of an applications guide which is intended to provide the user with step-by-step guidance on the use of models in optimum ventilation design. This guide, which is due to be published in March 1986, has been structured in such a way that the most appropriate type of algorithm according to building type and ventilation need can be rapidly identified. References are made to published computer programs, while basic data, necessary to perform calculations, are contained within the guide itself. It is hoped that some of the concepts presented in this guide will prove of value to a moisture annex.

References

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FIGURE 1: Moisture content of saturated air

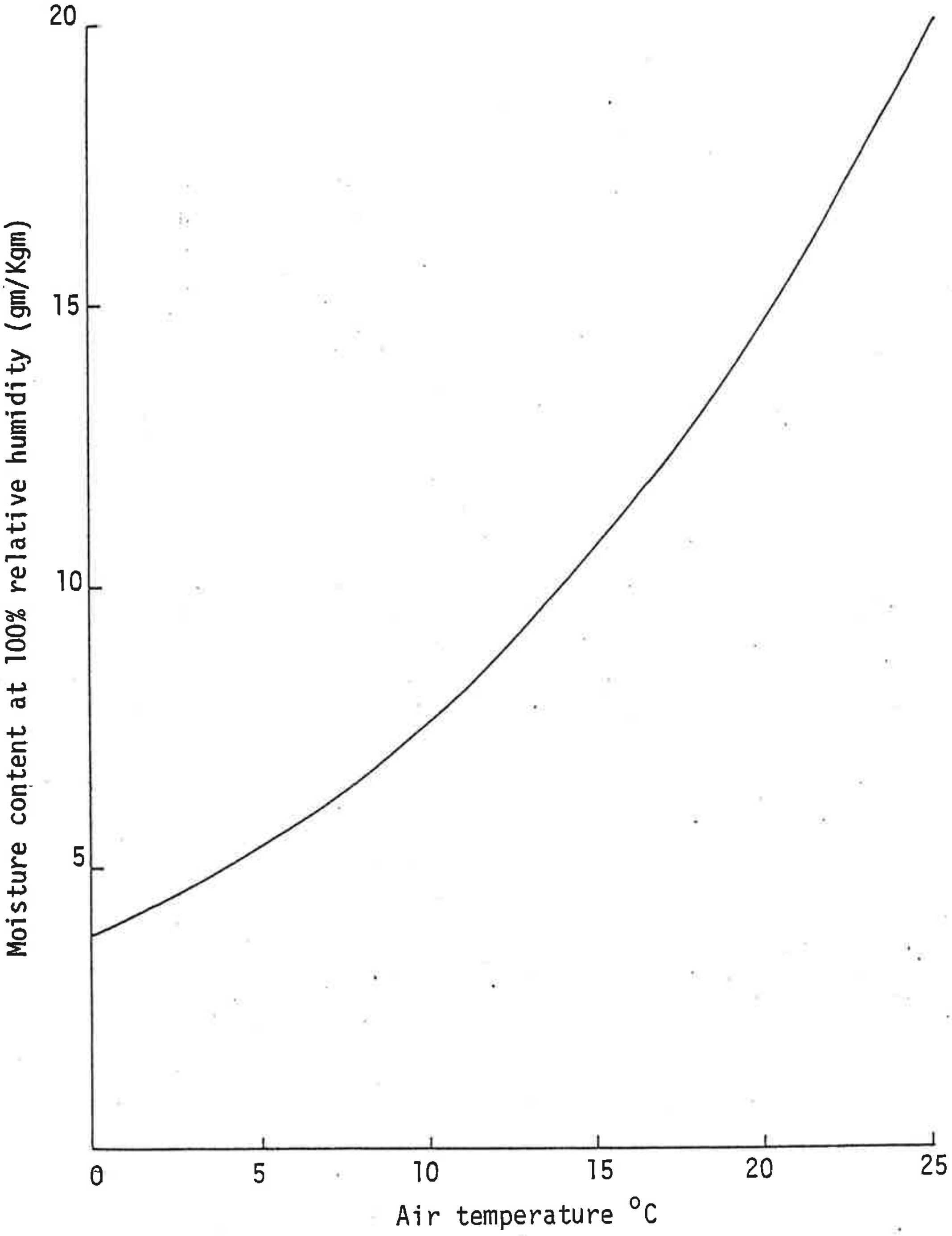

FIGURE 2: Average seasonal moisture content of infiltrating air

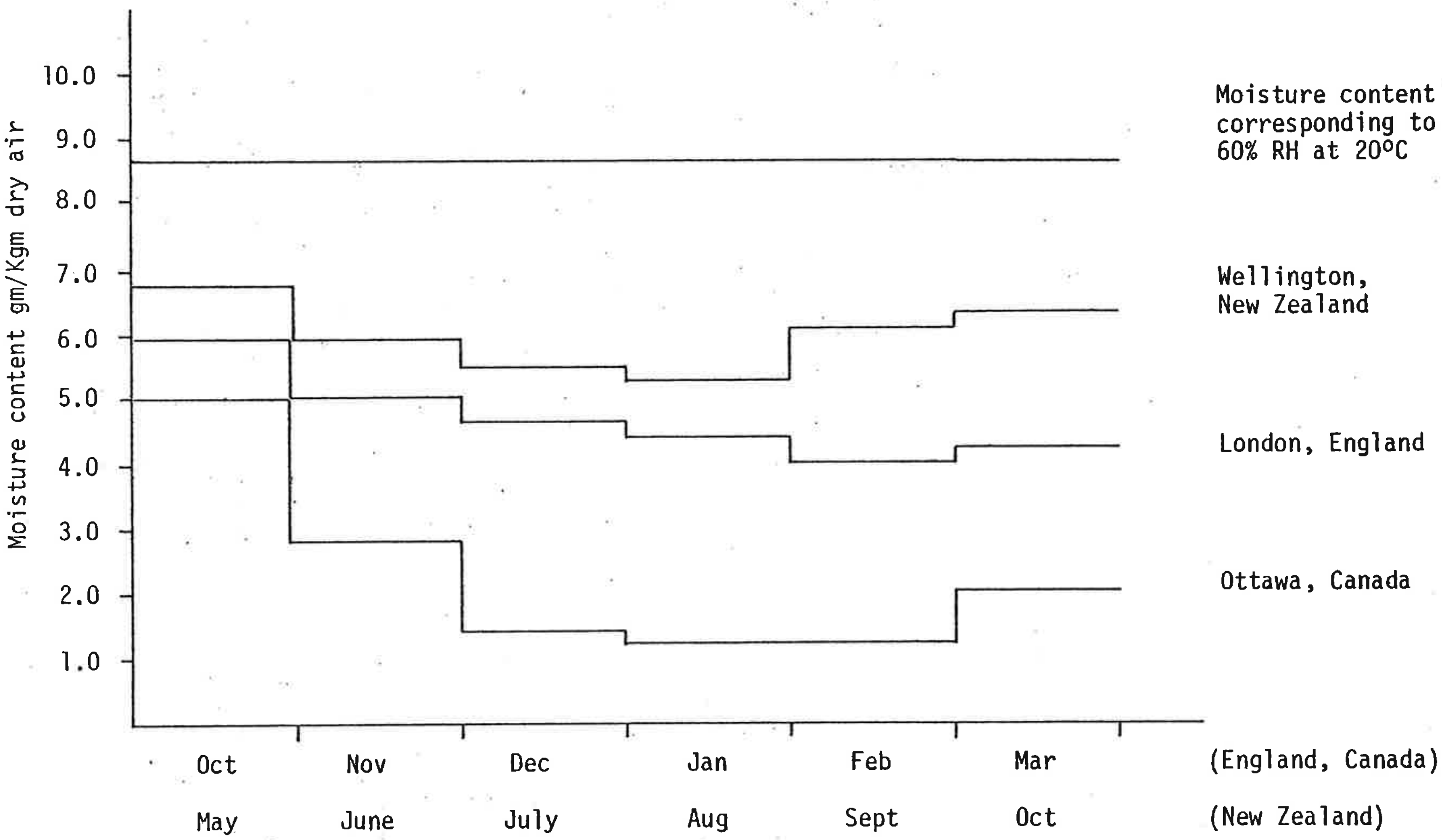

FIGURE 3: Ventilation requirements to dilute some common domestic pollutants