VAPOUR DISTRIBUTION AND VENTILATION IN EDUCATIONAL BUILDINGS

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An investigation sponsored by the Department of Education and Science

INTRODUCTION

The investigation was commissioned by the Department of Education and Science, Architects and Building Branch, with the object of assessing whether there is evidence that atmospheric moisture and other pollutant levels have generally increased in Educational buildings as a result of design and construction changes; and whether there is a consequential increased risk of condensation and deterioration of the building fabric. It was hoped to examine the current design guidance for environmental standards, and to assess whether there is a need to revise the guidance given on the design of buildings, both in relation to achieving an appropriate balance between energy conservation and the needs for the health of the occupants and durability of the buildings.

The study was intended to commence in October 1984 but was delayed until February 1985, as key personnel were not available for interview until that time. The finance available for the study has not allowed interviews to be held with a number of individuals who might have provided further useful information. This report is in a summary form and must be considered as an interim statement. It may be necessary to consider an extension of the commission in order to be able to produce a more conclusive statement.

LITERATURE SURVEY

The study has involved a literature survey and a study of recent research on related subjects both in the UK and from abroad. From this, it may be concluded that in recent years there has been considerable research by a large number of individuals and a variety of organisations. In some instances this has been incorporated into official guidance in the form of Codes of Practice, but in many more instances remains as a commentary on the state of the art. It results in a situation where much of the guidance must still be questioned in terms of its scientific validity, the ease with which it can be understood and adopted, and its effectiveness in practice.

THE INTERVIEWS

Interviews were held with 10 Local Authorities who provided the personnel best equipped to discuss the subject. In consequence a relatively wide range of experiences was sampled. Discussions were held with Michael Hohman of the GLC Technical Policy Unit and Ian Bealby of the GLC Scientific Branch. The Consortium for Method Building provided information from various studies carried out into particular problems. Meetings were held with Dr. Peter Warren of the Building Research Establishment and Peter Jackman of the Air Infiltration Centre both of whom provided valuable information. There were others with whom interviews would have been of value, but limitations of time and money have necessarily conditioned the extent of the survey.

CONDENSATION IN EXISTING BUILDINGS

There was a general and uniform concensus that problems in relation to condensation in Educational buildings were very few. In comparison with other problems with which those interviewed were involved, it might be classified as insignificant. However, most authorities could identify where condensation had been an embarrassment, if not a serious problem for some particular projects. Post war buildings presented more problems than those built before 1939. It was evident that the identification of a particular cause of the presence of water was often complicated. There appear to be a significant number of occasions where condensation had been identified as the cause without recognising that the problems originated from water penetration at an earlier stage, or from insulation materials in a wet condition; the inclusion of a vapour barrier in such conditions only serving to exacerbate the problem. This is particularly the case with several flat roof systems and notably where fibre insulation board is used with felt or asphaltic coverings. More recently pitched roofs have provided their share of problems. Several instances were quoted where corrugated metal roof coverings on shallow pitched roofs had resulted in water penetration and/or condensation.

Other areas were identified in particular situations involving thin skin opaque panels, curtain walling and particular design solutions which resulted in cold bridging and consequential excessive surface condensation. This was also evidenced where a combination of environmental conditions resulted in surface condensation on hard plastered walls and dense concrete floors. In these situations it appeared that lack of ventilation, combined with very low night time temperatures, was most usually the cause.

It appears that the problem of condensation seldom arises after the drying out period following building construction, unless there is a particular design or construction fault, or a change of use. Surface condensation is usually self evident on windows and dense wall surfaces, such that any reaction by the occupant will usually result in some remedial action which will remove or ameliorate the condition. Condensation on the surface of a floor invariable presents a hazard and must be dealt with expeditiously. However, condensation is not always evident on surfaces which are absorbent. The wetting-dryng cycle may be such as to give no visual effect unless moulds develop on the surface or decorations are disfigured. What is not known is the extent of any interstitial condensation and the potential for subsequent detioration of the fabric, particularly where this comprises organic materials. There are cases where authorities have removed ceilings and linings etc in order to investigate internal surfaces more closely. SCOLA has carried out a detailed monitoring exercise for all marks of the Consortium's building system with several of its member authorities involved in such detailed investigations. The results support the view that condensation is very limited and in very few cases is a primary cause for deterioration of the fabric. Generally, those who have been most innovative have most problems.

ENERGY CONSERVATION AND VENTILATION STANDARDS

All authorities have energy conservation programmes for existing buildings. The major economy is achieved by better servicing of heating installations and the introduction of improved controls. The addition of cavity wall insulation and the reduction of adventitious infiltration are the next most effective methods employed to a varying degree by a proportion of the authorities. The majority of authorities have schemes to explore other methods of reducing heat loss and to conserve energy. However, there appears to be a wide variation both in the skill and understanding with which refurbishment and energy conservation schemes are executed. Some are recognised as introducing an element of risk. As an example, in one authority the reduction of frost thermostat settings resulted in excessive surface condensation. There were adverse user reactions and also some concern for the potential interstitial condensation which might advance the deterioration of the fabric. Consequently thermostat levels have since been raised; it being noted that the fuel economy was not significantly affected.

Draught sealing of opening lights and doors is undertaken with some reservation both in terms of its effectiveness and value for money, and for the possible effect on ventilation levels within the occupied space. However, there is a body of opinion which considers that most schools are significantly over-ventilated.

There are strong pressures to reduce the ventilation standard, it being affirmed by those who have observed conditions in existing buildings that the design levels for ventilation are not being realised during the coldest periods of the year, as occupants keep windows closed in order to maintain adequate temperatures. Regrettably the observations are not supported by sufficient scientific analysis of the conditions at the time. The questions which must be asked are: What ventilation rate is being achieved? Is it a significantly low level? What proportion of the occupants find it acceptable? Is it detrimental to their health?

Research into environmental conditions in primary school buildings during differing weather conditions is limited. There is a considerable amount of information on temperature levels, less on humidity and very little on ventilation. For secondary schools the situation is considerably worse. When the investment in secondary school buildings is compared with that in primary schools it is evident that the amount of research at secondary school level does not compare favourably with that in primary schools. Yet it is certainly the case that the potential for poor environmental conditions is much greater in the former. Individual spaces in many secondary schools, often the most critical in the terms of density and continuity of occupancy, are often under-ventilated, but it is disturbing to note how little is known about the incidence and what are the contributory factors. Neither is there any evidence from research to show whether under-ventilation is a growing trend or otherwise. Indeed, it would appear that the current research by Dr. Warren for the DES will not have given adequate consideration to secondary schools.

ENVIRONMENTAL MANAGEMENT POLICIES

The attitudes and experiences with regard to management policies for energy conservation in schools appear to be highly variable. Designers of buildings may have a clear appreciation of how the building should be managed, but this is not necessarily communicated to the users. Many of the finer points with regard to the efficient maintenance of systems and conservation of energy are not appreciated by the occupants.

Energy conservation incentive schemes have been introduced with enthusiasm by some and with reservation by others, mainly it appears in selected secondary schools. There are others who are resistant to the use of such schemes. There are evident dangers of which most authorities are aware, but not in sufficient detail nor with sufficient knowledge on the effect on attitudes of teaching staff, resultant ventilation levels and consequence for the health of occupants. It is a maxim that a user's approval of a building is proportional to the facility with which he can exercise control of those factors which might affect his sense of well-being. However, it does appear that very little individual control is provided when it comes down to heating. Within the classroom, the teacher may be in nominal control, but has little opportunity to control the environment except by opening or closing a window.

INTERNAL ENVIRONMENTAL STANDARDS AND CONDENSATION

The most significant factors which normally influence the moisture content in the atmosphere for a particular building are the external climate; the numbers and activities of occupants; the machine and equipment processes which generate heat or moisture; the method and rate of ventilation.

We have no control over the external climate. Britain enjoys an equable maritime climate, which means it is predominately wet and humid. It follows that any net gain in moisture levels within a building requires a relatively high ventilation rate for the removal of any excess, and any artificial drying process must respect the same equation. Consequently, the designer must beware any solution which does not recognise this basic fact.

The numbers of occupants within education buildings are highly variable as are the activities in which they are involved, varying from the extremes of a high concentration of children within an internal area without natural light, such as a drama hall or lecture theatre, or a lower concentration such as in a science room , to relatively few children in a light, airy gymnasium or sports hall.

Other sources which generate moisture have to be taken into consideration. For schools these are normally concentrated in kitchens, changing rooms, shower areas etc. It is generally recognised that such areas are provided with means to mechanically extract excess moist air. It does not follow that they are always used. However, the limited period of occupancy in schools, combined with the extended holiday breaks, and the considerable movement of children and staff whilst in occupation, results in environmental conditions which are very unlikely to create unacceptable moisture conditions for normal, traditional construction. Any change of occupancy or pattern of behaviour which would lead to reduced levels of ventilation and consequently higher moisture content could produce the situation which might cause problems of interstitial condensation. Buildings constructed to the current environmental and thermal insulation standards are most unlikely to suffer any problems with regard to condensation.

The question remains: 'What levels of ventilation and moisture content are actually experienced in practice?' This investigation has revealed no substantive data to provide an answer to this question.

INTERIM CONCLUSIONS

Condensation in educational buildings is not a significant problem. Given the continuation of the present standards for temperature and ventilation rates there is no reason to believe there should be any problems for future buildings. However, there is a body of opinion which advocates a reduction in the prescribed ventilation standards and in some cases this may be happening in practice. It is not reasonable for the LA's to proceed with the design of new schools, or with general programmes of refurbishment, which will result in changed environmental conditions for occupants of schools, without more knowledge of the conditions which presently obtain.

It is also most important for there to be more investigation into the effect of differing environmental conditions on the health, comfort and educational performance of occupants, particularly for secondary schools.

It is anticipated such research will identify a relatively broad band of temperature and humidity levels, but there will be a relationship between humidity and CO_2 levels such that the tolerance limits will be more closely related than is at present assumed. This may allow reduced ventilation levels to be adopted with the aim of reducing energy consumption, subject to a more critical design appraisal of individual spaces and their juxtaposition to one another.

It is to be hoped that the research for the DES on ventilation by Dr. Peter Warren of the BRE will provide a better understanding of some of these relationships, at least for primary schools. It may be possible to extrapolate from his findings to an application for general classrooms in secondary schools, but the range of activities and variations in some of the equipment, which also has an effect on the environment of specialist rooms, will almost certainly dictate that more research is necessary, and in greater depth, if guidance is to be given with assurance.

As a prediction it might be anticipated that levels of ventilation may be more directly related to the individual occupant (minimum CO_2 health standard) and thereafter administered in relation to operational levels of particular spaces in terms of the ventilation rate (litres/sec or m^3/hr of external air). This would take account of the particular requirements of specialist activities in chemistry and heavy craft rooms, resource centres, gymnasia, etc. It is evident that this specific kind of guidance is required not only for new buildings but is also important for the refurbishment of existing buildings.

INTERIM RECOMMENDATIONS

The following is a list of the most salient points which arise from the survey and require more careful consideration and possible research. Certainly guidance is required on them:

More analysis/monitoring of what has been experienced in terms of ventilation and humidity levels in existing buildings.

Human reaction to a changing environment is poor. There appears to be a need for the introduction of automatic sensors for temperature or CO_2 levels which will assist the occupants in the control of their environment, thereby reducing problems of discomfort and potential risk to health.

Children should be given a better understanding of how a building functions; the education curriculum should relate scientific studies more directly to the built environment.

The concept for the control of interstitial condensation by the use of vapour barriers is naive and is difficult to achieve in practice. An alternative and more effective practice is required.

The addition of roof and wall insulation, preferably applied externally can only improve the situation with regard to condensation.

The addition of insulation internally without a very careful analysis of the consequences for interstitial condensation is not recommended.

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