MOISTURE IN BUILDINGS

How to keep buildings dry enough to keep them healthy

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Abstract

This paper describes our greater awareness of the factors involved in deciding whether a given indoor environment is regarded as good or bad. Many of the mechanisms that create a bad environment require, or are exacerbated by, the presence of moisture, either in the structure or in the air. The most important measure in creating a good internal environment is therefore to ensure that moisture does not get to where it should not be. The paper describes means of preventing this, and describes the importance of ventilation, partly as a means of preventing moisture access or attack and partly as a complement to other measures.

Background

Hitherto, a good indoor environment has been concerned only with thermal comfort. Its criteria have been temperatures, draughts and operative temperature. However, in recent years, various other problems have come to the fore, such as indoor air pollution, odour, noise and other irritants, often associated with problems in the form of tiredness, headaches and other physical symptoms. Sometimes it has been possible to trace the cause: in recent years problems have been identified that were previously non-existent, or of which we were not aware. The release of formaldehyde, odour from mildew and self-levelling floor compounds are examples of such mechanisms, as is the emission of radon from building materials and the ground.

Inadequate or incorrect ventilation often contributes to increasing the concentration of pollutants and making problems noticed.

In order to ensure a good indoor climate, the most important first step is to eliminate or reduce the emission of pollutants to the indoor air. This can then be followed by planning for good ventilation.

The presence of moisture is an important prerequisite for the decomposition of the majority of materials, and thus also for the emission of pollutants to the indoor air. Moisture accelerates ageing processes and reduces life. The majority of forms of damage to buildings, i.e. not merely problems associated with the indoor environment, are probably caused by moisture. This is very disturbing, particularly when taken together with the fact that practising engineers and designers know little about moisture transport mechanisms or moisture calculations. They may be thoroughly familiar with the design of static systems, but they are less familiar with building physics calculations.

Knowlege of moisture conditions in and around structural features is necessary in order to be able to make a correct assessment of the risk of future damage. Proper design of structural features, selection of the right materials that can be relied on even in the long term not to become a source of hazardous emissions, and sensible use of the building ensure that it will be healthy from the start and also remain so.

Sources of moisture

When designing a structural feature in terms of its ability to withstand or protect against moisture, consideration must be given to the following factors.

Precipitation in the form of rain or snow tends to fall on the roof, which must be able to carry away large quantities of water without leaking. Driving rain, i.e. rain in combination with wind, strikes also vertical surfaces of the building. Exterior walls must be capable of withstanding this loading, as must windows and doors.

Surface water on the ground can flow towards the building and damage the foundations if the ground slopes the wrong way. In order to prevent this, the ground should slope away from the building: if this is not possible, the structure must be designed to withstand water pressure.

Water in the ground can be drawn up towards the building by capillary action in various materials. Such moisture migration can be prevented by protecting the foundations by a layer of gravel that breaks the capillary link up to the foundations themselves. Moisture also migrates in the form of diffusion from damp ground. In the long term, this can result in the same level of moisture in and around the foundations as caused by capillary attraction, unless special measures are taken to prevent it.

Locally, leakage of water from pipes and internal systems can result in heavy moisture loadings. Visible routing of pipes and careful positioning of apparatus can reduce the risk of such damage.

Moisture incorporated in structural materials at the time of building must be allowed to dry out. As far as possible, such drying out should take place before the building is completed. As it is often not possible to dry out all moisture in this way, the structural design should be such that moisture can continue to dry out after completion.

Moisture carried in the indoor air can create condensation in the interior of the structural elements, partly through diffusion from the interior towards the exterior and partly by convection. In this context, convection refers to the transport of moisture in air currents. Moisture convection can cause damage if warm, moist indoor air flows through the structure and, on its way, comes into contact with cold surfaces upon which condensation occurs.

The design of moisture-resistant structural features

The following principles for design and use of structural features in buildings should be applied, not only in new buildings but also when rebuilding parts of existing buildings. Compliance with them will ensure that buildings remain dry.

A. **Prevent moisture from reaching parts of the building** by employing:

- impermeable layers
- layers intended to carry away water
- drainage
- capillary breaks
- temperature elevation.

The use of impermeable layers must be suited to applications and conditions. Correctly used, an impermeable layer will result in a dryer structure than a similar structure without such a layer. On the other hand, a structure incorporating an incorrectly applied or employed impermeable layer will instead tend to trap moisture that would otherwise have dried out and become considerably damper inside. Any impermeable layer should prevent the undesired transport of moisture without causing unnecessary risks.

Water must be led away. This applies, of course, primarily to the roof, which is exposed to rain and snow, and where water should not be allowed to remain standing for longer periods. However, it also applies to window sills, drip plates over doors and windows and at joints between parts of the building.

Water in the ground must not be allowed to flow towards the foundation structure, but must be drained away.

It may be necessary to incorporate a capillary-breaking layer of gravel in order to prevent groundwater from being drawn up and to maintain the structure permanently dry. It is also generally good practice to prevent capillary transport between moist concrete and wood: a damp-proof course of building felt or some other membrane should always be incorporated there.

By raising the temperature of a structural element or part of a building, conditions are made less favourable for the transport or water vapour from moist areas. Temperatures can be raised either through active heating or by the addition of thermal insulation.

B. Heat parts of a building

A part of a building can more easily be protected against the damaging effects of moisture if its temperature is elevated. This can be done actively by means of a heating cable or hot pipes, as is often done around the perimeter of a slab floor in order to prevent damage and to ensure that the floor is warm. It can also be done by the application of external insulation to the structure. By insulating the exterior of that part of the building that is sensitive to moisture, its temperature will be raised closer to that of the indoor temperature, which should normally prevent damage from arising. This will extend the life of the structure and reduce the risk of emissions.

Heating of buildings and parts of buildings should be constant and continuous. Intermittent heating always involves increased risk of damage. As intermittently heated structures sometimes have temperature gradients in one direction and sometimes in the other, moisture can migrate upwards, e.g. from warm, moist ground. In a basement or cellar, floor heating should remain on throughout the year, so that even in summer condensation in the floor is prevented, with its otherwise associated risks of odour, corrosion and other deterioration.

C. Provide ventilation where moisture can occur

In many cases, ventilation can be employed to ensure that roofs, walls and floors are kept dry. By ventilating away moisture, building elements can be maintained dry, while even if moisture should get into them, it can dry out before damage is caused. Ventilation often provides additional security against damage.

Normally, we attempt to design ventilation systems so that the air is moved by wind pressure or thermal forces, although in difficult-to-ventilate spaces, where ventilation is essential, such as under low roofs or beneath floors, it may be necessary to resort to fans.

In such applications, the ventilation system should be designed so that damage caused by convection is avoided. In ventilated areas, the air should always move from a lower temperature to a higher temperature area. In a ventilated underfloor space, the air should be drawn in along or through the exterior wall and towards the centre of the building, from where it is then evacuated. Travelling in this direction, the air can pick up an increasing quantity of moisture. If it flowed in the opposite direction, from a higher temperature to a lower temperature, there would be a risk of condensation being formed as the air was cooled.

D. Use the building properly

This means making sure that the building is properly ventilated, i.e. with fans and extractions arranged in kitchens, laundry rooms and bathrooms and in other areas where moisture can be generated or released. The occupants of the building should also understand the importance of ventilation and temperature in controlling relative humidity indoors.

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The design of healthy buildings

Materials and structural features of healthy buildings should be designed as follows:

1. Use materials of which both the present and future properties are known. The materials should not themselves emit pollutants or contribute to other materials or structural or design features becoming unhealthy.

2. Design structural features and combine materials in such a manner that problems cannot arise. Build dry.

3. Design the ventilation system so that all spaces are correctly ventilated. Check the performance of the ventilation system at the time of installation and when the system has been in operation for about a year or so. Draw up clear and easily-understood operating and maintenance instructions.

A building that has been designed and constructed with these guidelines in mind will be a healthy building. However, this does not necessarily mean that the indoor environment will be healthy: the activities carried on in the building can release pollutants as can the interior finishes, fittings and equipment.

Testing and evaluation

New designs should be tested and evaluated in terms of their safety to health and performance in respect of, and in relation to, moisture. Methods of calculation provide an important aid: calculations can be used to check the moisture status of a structural feature under normal circumstances with the assumption of a standard climate on both sides. Conditions with extremes of indoor and outdoor climates can then also be checked to assess the performance of different designs relative to each other.

Laboratory testing of structural elements can expose them either to standard climate on both sides or to extreme climates. Moisture variations in real structures can be investigated and compared with the theoretical values.

Test buildings are used to investigate the behaviour of design and structural features in natural outdoor climates. Indoor climates can be varied as required, establishing either a standard climate or more extreme values.

In the case of full-scale trials, i.e. investigations of existing buildings etc., trial conditions are more or less restricted to those actually encountered indoors and outdoors.