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Advanced moisture calculations – web site information

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Safety and Health in Buildings

Advanced calculations of moisture movement in structures

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Interim Report

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Prepared by	Mr C H Sanders BRE Scotland
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Approved on behalf of BRE

Signature	
Name	Dr Stephen L Garvin
Position	Director of BRE Scotland
Date	

BRE Scotland
Kelvin Road
East Kilbride
Glasgow
G75 0RZ

Tel : 01355 576200
Fax : 01355 576210

Email : eastkilbride@bre.co.uk
Website : www.bre.co.uk

Executive Summary

Interstitial condensation is a significant risk in all types of building, leading to problems ranging from staining of interior décor, as the condensate leaks back into the building, up to damage to the fabric that can affect the structural integrity of the building. BRE has recently finalised guidance that will be available in 2004 that is intended to be used by those involved in the design and construction of buildings. It provides information on the theory and models used in interstitial condensation assessment. The information in this report will be placed as a summary on BRE's web site for the information of potential users.

The advanced models for moisture modelling described in the guidance are as follows:

- BRECON
- ICOND
- Advanced models - A number of commercially available software packages, can be used for the calculation of interstitial condensation and moisture movement within structures. The most commonly used in the UK is the dynamic heat and moisture transfer program MATCH (Moisture and Temperature Calculations for Constructions of Hygroscopic Materials).

Knowledge of materials properties are required for the calculation methods, these include the following:

- Thermal conductivity
- Vapour permeability
- Density
- Specific Heat Capacity
- Porosity
- Water sorption coefficient
- Sorption Isotherm
- Liquid water diffusivity
- Emissivity.

Internal and external conditions need to be taken into account in using the models. Advice on minimising interstitial condensation is also provided in the guidance.

Contents

1 Introduction

Interstitial condensation is a significant risk in all types of building, leading to problems ranging from staining of interior décor, as the condensate leaks back into the building, up to damage to the fabric that can affect the structural integrity of the building. Concerns are now being expressed about the severe health implications of the growth of so called 'toxic mould' that can occur when condensation persists within structures. Changes in construction, especially the use of more thermal insulation and impermeable claddings and the trend toward offsite manufacture of building elements may increase these risks.

BRE has recently finalised guidance that will be available in 2004 that is intended to be used by those involved in the design and construction of buildings. It provides information on the theory and models used in interstitial condensation assessment. The information on the web site provides a summary of the guidance, which is intended to highlight the importance of this area and the contents and use of the guidance.

The method for analysing the risk of interstitial condensation within a structure was first developed by Glaser in Germany in the 1950s. This was the basis of the procedure specified in Appendix D of BS5250:1989. This was the basis of a number of software packages, including the BRE program 'BRECON', that have been widely used by industry over the past decade. This method was further extended by publication of BS EN ISO 13788:2002, which is referenced in the latest edition of BS5250.

2 Calculation methods

2.1 BRECON

BRECON is a software package developed by BRE to carry out the calculation procedure specified in Appendix D of BS5250:1989. While this procedure is now superseded, the package is the only one available that can allow for the effect of ventilating a cavity within a building structure.

The structure to be analysed is divided into a series of parallel layers, each with uniform thermal resistance, $R_{t,i}$, and vapour resistance, $R_{v,i}$. The layers are usually chosen to consist of a separate material, however, a monolithic construction or an individual thick material layer can be subdivided if there is a chance of condensation occurring within the layer. The accumulated thermal and vapour resistance from the inside to each interface between layers, is calculated, and used to determine the temperature and vapour pressure (VP) at each interface, given appropriate boundary conditions. The saturated vapour pressure (SVP) corresponding to the temperature at each interface is calculated; if this exceeds the vapour pressure at all interfaces, no condensation is predicted. To illustrate the process the programme produces a profile through wall sections.

BRECON is a useful tool for those involved in new build or refurbishment work. It is quite usable given a reasonable amount of training or instruction. However, due to the complexity of subdividing a structure with condensation planes and ventilated cavities, it is possible to analyse only one ventilated cavity and only one condensation plane in a structure with a ventilated cavity.

2.2 ICOND

The new British Standard Code of Practice for the control of condensation in buildings, BS5250:2002, came into force on November 1st 2002. This makes reference to the calculation procedure in BS EN ISO 13788:2002, which is implemented in the software package ICOND, which is under development. At present the package is usable and gives results, which comply with the standard, and is being developed to remove bugs and make it more user friendly. Ventilation of cavities may be included as part of this development.

In the EN 13788 method the same calculations as specified in the BS5250:1989 method are carried out using boundary conditions representative of twelve months of a year (see Section 4). The monthly accumulation and evaporation of condensation from each interface between materials within the structure is calculated, and the following three criteria are used to assess the structure:

a) No condensation predicted at any interface in any month: the structure is reported as being free of interstitial condensation.

b) Condensation occurs at one or more interfaces but, for each interface concerned, all the condensate is predicted to evaporate during the summer months. In this case the maximum amount of condensation that occurred at each interface, and the month during which the maximum occurred is reported. The risk of degradation of building materials and deterioration of thermal performance as a consequence of the calculated maximum amount of moisture is considered according to regulatory requirements and other guidance in product standards.

c) Condensation at one or more interfaces does not completely evaporate during the summer months. The structure has failed the assessment as it is assumed that further condensate will accumulate from year to year.

2.3 Advanced models

- A number of commercially available software packages, can be used for the calculation of interstitial condensation and moisture movement within structures. The most commonly used in the UK is the dynamic heat and moisture transfer program MATCH (Moisture and Temperature Calculations for Constructions of Hygroscopic Materials). MATCH accounts for moisture transport by vapour diffusion and liquid suction, and therefore considers not only the vapour permeability but also the moisture retention properties of materials. MATCH has an extensive database of material properties, covering most common building materials.

2.4 Air infiltration into a structure

In some structures, such as timber framed walls, timber flat roofs and especially domestic pitched roofs, warm humid air from the inside of the building can penetrate the structure to reach cold areas on the outside of the insulation. As moisture transfer by air movement is much greater than that by diffusion through materials, this can add greatly to the rate of condensation, exacerbating problems. Common routes are the joints where walls meet ceilings and floors and between lining boards and through penetrations such as electrical sockets, plumbing fittings, hatches and light drops. The air flows can be much more important, in buildings, such as operating theatres, electronics factories or other clean rooms, which are operated at an over pressure to reduce ingress of contaminants

3 Material properties

3.1 Properties needed for modelling interstitial condensation

To model the risk of interstitial condensation within a structure, some information about the properties of the materials present must be available. This can be simple 'common sense' information such as steel sheets are impermeable to water vapour or mineral wool is permeable, that can be helpful when carrying out a preliminary assessment of whether a structure is likely to give problems and when an analysis method is being chosen. At the other extreme, if a full analysis using the advanced calculation techniques described above is necessary, detailed information on the thermal and moisture properties of each material and the ways in which these properties respond to changes in temperatures and moisture content, will be necessary.

The simple properties needed for EN 13788:2002 calculations are generally, but not universally, available and standardised measurement methods exist. However, this is not the case for the more complex properties needed for advanced calculations; measured data are available for few materials and the methods for measuring many of the parameters have yet to be standardised.

Only two material properties are necessary for BS EN ISO 13788:2002 calculations:

- Thermal conductivity
- Vapour permeability

Information on many more parameters, as well as the thermal conductivity and vapour permeability described above, is needed for more advanced calculations as follows:

- Density
- Specific Heat Capacity
- Porosity
- Water sorption coefficient
- Sorption Isotherm
- Liquid water diffusivity
- Emissivity

4 Boundary conditions

To calculate the risk of condensation or the movement of moisture in any structure it is necessary to assume appropriate internal and external environmental conditions.

Table 1 shows the types of buildings expected to fall into each class and the range of relative humidities covered by the class in buildings with different internal temperatures, at an external temperature of 0 °C and a relative humidity of 95 %.

For calculations, it is recommended that the upper limit value for each class be used unless the designer can demonstrate that conditions are less severe.

Table 1 - Internal humidity classes : Building types and limiting relative humidities at Te = 0°C

Humidity class	**Building type**	**Relative humidity at internal temperature**		
		15 °C	**20 °C**	**25°C**
1	Storage areas	<50	<35	<25
2	Offices, shops	50 – 65	35 – 50	25 – 35
3	Dwellings with low occupancy	65 – 80	50 – 60	35 - 45
4	Dwellings with high occupancy, sports halls, kitchens, canteens; buildings heated with unflued gas heaters	80 – 95	60 – 70	45 – 55
5	Special buildings, e.g. laundry, brewery, swimming pool	>95	>70	>55

For external conditions the following parameters are required:

- External air temperature is the most important parameter in all construction types as it determines the temperature in the zone outside the insulation, where condensation is most likely. This can be modified by the effects of radiative cooling and heating in some construction types.
- The loss of long wave radiation to a clear night sky can cool the external surface of a building several degrees below the air temperature significantly increasing the rate of condensation.
- Conversely, solar radiation warms the external surface and can aid the evaporation of condensation that has occurred in colder periods.

- External vapour pressure is strongly linked to external temperature, and is, in any case, of secondary importance in systems with impermeable outer layers.
- Wind speed can be relevant in a number of complex ways.
- Rain falling on roofs, or being driven by the wind against walls increases the moisture content of components.

5 Controlling interstitial condensation

To minimise interstitial condensation, it is necessary to do one or more of the following:

- obtain low vapour pressures by ventilation, and/or reduced moisture input to the building;
- use materials of high vapour resistance near to the warmer side of the construction;
- use material of low vapour resistance, or provide ventilated cavities, near the colder side of the construction;
- use materials of low thermal resistance near to the warmer side of the construction;
- use materials of high thermal resistance near to the colder side of the construction.

6 Conclusions

A number of methods of calculating and modelling interstitial condensation have been assessed by BRE. Information on the various options has been included in the guidance. The link to the guidance will appear on the web site when it is published.

A Powerpoint presentation on the guidance and generally on the subject of interstitial condensation is included in Appendix A.

Appendix A - Powerpoint presentation: Interstitial Condensation