

Material decay and health issues in modern construction

1. Introduction

This paper was written by members of the Mould Discussion Group UK (Linked In) following a suggestion from Dr Graham Atherton of the Fungal Research Trust and Aspergillus.org.uk web site, operated /promoted by the National Health Service. The worldwide group membership listed in the appendix have provided their opinion in an attempt to assist the householder, landlord or tenant with an explanation of recognised material damage and decay issues associated with the growing problem of water damaged buildings WDB and their related health hazards.

- 1.1. Water damaged buildings are considered to be any dwelling or building where moisture in any form including, condensation and flooding has resulted in elevated humidity or moisture content above generally accepted levels of equilibrium.
- 1.2. The issues and ramification of WDB is often the bio amplification of naturally occurring organisms or release of chemicals to levels which may have either short or long term health effects on susceptible building occupants.

2. Overview

Uncontrolled water or moisture in a building can lead to material decay but most importantly serious health issues to susceptible building occupants or indeed visitors. These health effects can be attributable to the known bio amplification of bacteria, mould and associated chemicals often referred to as volatile organic chemicals released by organisms or building materials and these include known carcinogens such as formaldehyde.

The health hazards of mould and bacteria may only affect part of the population generally identified as “atopic” and their susceptibility may revolve around the state of their immune system reflecting age, general health and genetics.

The health issues may be seen generally and broadly as caused by exposure to allergenic or toxic components of the bio amplification and dose in terms of time and or levels of exposure may be significant factors. This paper attempts to identify the cause of bio amplification and its main component factor in buildings, water.

3. Systemic Building Failures

3.1. Water damage buildings may reflect the systemic construction failures over the past 30 years as identified by the Building Research Establishment ¹

These include:²

- 3.1.1. Deterioration of pre-cast concrete
- 3.1.2. Moisture penetration of external insulation (EIFS)
- 3.1.3. Failure of structural insulated roof panel systems

¹ BRE

<http://www.nhbcfoundation.org/LinkClick.aspx?fileticket=%2ByHbjZ7R3QU%3D&tabid=339&mid=774&language=en-US>

² NHBC foundation Housing research and development in partnership with BRE Trust

- 3.1.4. Systemic failures in design and construction standards
- 3.1.5. Failure in detailing issues of innovative construction
- 3.1.6. Unproven resilience issues
- 3.1.7. Thermal and moisture bridging issues within building envelope

4. Summary

The UK now leads the world in two significant areas, the regulations and process for the reduction in greenhouse or carbon emissions from buildings and the unfortunate rise in asthma which may or may not be related.

- 4.1. The relationship could be seen as the quest for energy saving measures which was initiated following the oil prices of the 1970s and the continuing rise in fuel costs and asthma or respiratory problems appear to follow similar growth patterns.
- 4.2. Energy conservation is basically the retention of heat and reduction of heating or running costs. The European heating climate usually has outside or ambient temperatures below the normally accepted 18 -21c comfort living range. Measures to reduce the ever increasing heating costs have been enshrined in both building regulations³ and the quest for lower fuel bills by the homeowner and tenant
- 4.3. The introduction of new construction materials and design and building regulation may have had a detrimental effect on the traditionally accepted householder lifestyle issues.
- 4.4. Fuel poverty where householders struggle to keep their homes warm due to rising costs can also increase the potential for condensation from the trade off balance between heating and fresh air ventilation.
- 4.5. The exclusion of mould by many insurers in both new build guarantees and traditional home policies points to the increasing growth of the WDB and its liability and cost of repair or decontamination and perhaps even personal injury.
- 4.6. Mould growth and bio amplification are the direct consequence of uncontrolled moisture presence or movement within the built environment.
- 4.7. The presence of mould growth and bio amplification is associated with serious health effects in susceptible individuals.

5. New build issues

- 5.1. The general replacement of traditional brick walls which are heat retentive, with timber frame type construction has meant buildings heat and cool much faster increasing the need for a wider heating regime to avoid condensation or maintain a comfortable living environment.

³ Part L of the building regulations

- 5.2. The general removal of building control by independent local authority has seen a growth of self-regulation with the building industry resulting in a possible decline in build quality and building defect can often contribute to moisture and WDBs.
- 5.3. Design parameters sometimes see vapour barriers on wrong side of insulation
- 5.4. Ventilation requirements are often designed to revolve around the sole use of switchable fans such as bathroom extract although make up air is rarely provided.
- 5.5. Trickle vents for fresh air are sometimes not fitted to windows especially where condensing boilers are fitted.
- 5.6. Moisture retention of building phase is often ignored and some elements of construction may take 12 months or more to dry in a sealed environment.
- 5.7. Failure to incorporate adequate construction detailing and use of inferior material's⁴

6. Renovation of older buildings

The transformation of the older building stock to increase value or improve aesthetics has seen a revolution in both amateur renovation and often unqualified or competent work by those considered to be professional. The issues of professional often revolve around design rather than quality of work and the following are typical failures seen which result in WDBs.

- 6.1. Block work paving to gardens bridging DPC⁵
- 6.2. Blocking up fireplaces without proper ventilation to stack or replacement of natural air flow
- 6.3. Replacing windows with double glazed units without ventilation grills
- 6.4. Draft free windows and doors removing fresh air supply
- 6.5. Poorly installed roof or wall insulation with gaps to allow thermal bridging and consequential condensation
- 6.6. Replacement of wet rot floor boards with concrete floors ignoring the original cause of damp
- 6.7. Eliminating air flow from sub floor air bricks by concrete replacement of wood suspended floors, effectively removing sub floor moisture control.
- 6.8. Rising damp issues may develop but remain hidden due to modern wall finishes
- 6.9. The breathable original building design may be replaced by modernising techniques which eliminate fresh air ingress or indeed air exchanges.

7. General building failure points

- 7.1. Strong external renders attached to relatively weak substrate which crack on curing or during thermal expansion and allow water penetration
- 7.2. Embedded timbers especially floor joists touching wet walls and resulting in rot and mould growth
- 7.3. Corrosion or failures of cavity wall ties leading to structural problems
- 7.4. Penetrating damp likely to affect internal finishes and result in mould growth
- 7.5. Sulphate attack on bricks from mortar resulting in cracks between bricks and penetration points

⁴ Learning the lessons from systemic building failures. NHBC foundation Housing research and development in partnership with BRE Trust

⁵ Damp Proof Course

- 7.6. Application of non-permeable paints and finishes on both external and internal substrates
- 7.7. Roof or loft condensation issues caused by failures in ventilation and or insulation resulting in dew point condensation in the often cooler “cold roof” areas
- 7.8. Thermal pumping, the action of solar radiation and air expansion under metal roofing resulting in partial vacuum during rainfall (cooling) and the ingress of water.
- 7.9. Carbonation and resultant failure of concrete or mortar

8. Moisture build in today’s buildings

Uncontrolled moisture in a building is seen as the main source of building decay and often is associated with poor health of occupants⁶. Its main sources apart from lifestyle issues are;

- 8.1.1. Rain penetration through the structural envelope
- 8.1.2. Leakage from faulty services and appliances within the dwelling
- 8.1.3. Condensation of moisture vapour in the air
- 8.1.4. Groundwater via rising dampness
- 8.1.5. Moisture resulting from the water used in the construction process, eg in plasters and mortars, and from construction in wet weather
- 8.1.6. Flooding.

- 8.2. Apart from the obvious issues we are now faced with changes in our environment and extreme heat and cold and rainfall are likely over the coming years and it may be seen as imperative to identify current failures in order to reduce these potential impacts.

9. Mechanisms for water penetration

Water can enter the building envelope in liquid or vapour phase. Rainwater can enter through gravity, capillary action or surface tension and air pressure difference. Air pressure difference can originate from thermal pumping in unventilated buildings, wind forces, or pressure differentials between extract and make up air.

10. Humidity.

The quantity of moisture present in the air is referred to as specific humidity and this is either measured in grains per pound or kg/kg of dry air. In the UK we generally see ambient or outside specific humidity of around 4kg/kg. In a flood affected home on a warm day we might expect to see 14kg/kg. Specific or absolute humidity should not be confused with relative humidity. As evaporation occurs the air “specific humidity” will rise but equally the warmer the air is it expands in volume and its capability to contain more moisture increases, thereby reducing the relative humidity.

- 10.1. The amount of moisture in the air compared to what it could contain at its current temperature is known as “relative humidity”

⁶ Learning the lessons from systemic building failures. NHBC foundation Housing research and development in partnership with BRE Trust

- 10.2. In a home with poor ventilation but normal lifestyle issues we might see around 9kg/kg
- 10.3. In a WDB affected by leaks or severe condensation we might see levels at 12kg/kg
- 10.4. The average family of four produce around 3 gallons of water per day from normal lifestyle issues which includes, showering, cooking, breathing etc.

10.5. Example

A room temperature of 20c and with a relative humidity of 70% gives a specific humidity of 010kg/kg dry air. If the ambient or outside temperature is say 10c with a relative humidity of say 60% we have a specific humidity of approximately .0050kg/kg. This means the vapour pressure is pushing towards the external envelope of the building. The wet warm internal air wants to move to the dryer cooler external air under the second laws of thermal and hydrodynamics.

- 10.6. If the warm moist air travelling outwards touches surfaces cooler than the "Dew Point" at 14c the moisture in the air will condense on the cooler surface. This condensation factor will either remain on the surface of non-porous material's or more likely be adsorbed by wood, brick, plasterboard.

- 10.7. These surfaces may be cooler because of thermal or bridging, dampness or missing insulation, usually the result of poor construction detailing.

- 10.8. Once trapped in interstitial cavities the moisture may feed bio mass and dormant or active mould spores, generating bio amplification and potential health hazards in hidden areas.

- 10.9. From this example we can identify have five distinct issues

- 10.9.1. Moisture intrusion
- 10.9.2. Moisture generation (lifestyle)
- 10.9.3. Moisture movement
- 10.9.4. Moisture control or removal
- 10.9.5. Mould and or bio amplification

- 10.10. Apart from the obvious requirement to repair or control moisture development the major issue is drying or removing the moisture prior to its saturation of the air or indeed substrate. This can be achieved either through dehumidification or air exchanges, commonly called ventilation.

11. Heating and standards of comfort

Heating is the major cause for moisture to be adsorbed into the air. With evaporation from wet substrates being triggered by heat and warm air capability to become saturated easier than cold air, we see heat as a major issue in moisture movement and control. Too little heat and surfaces become cooler and even minor heating can cause substantial condensation even in fuel poor homes. Too much heat in a wet building and secondary damage can be expected as water vapour rises to previously unaffected areas such as loft, ceilings or upper floors generally.

There is no absolute standard of thermal comfort. An internationally-accepted definition of thermal comfort, used by ASHRAE, is 'that condition of mind which expresses satisfaction with the thermal environment' (ISO 7330). Perceptions of this environment are affected by air temperature, radiant temperature, relative humidity, air velocity, activity and clothing. More general definitions of comfort include a sense of relaxation and freedom from worry or pain

- 11.1. There is evidence of a lessening of physical and psychological distress when hard-to-heat housing in the UK is improved to provide a basic standard of ventilation and warmth
- 11.2. This standard is normally taken to be the one set by the World Health Organisation: 21°C for people in a living room and 18°C elsewhere in the home.
- 11.3. The UK has one of the highest levels of excess winter mortality in northern Europe. England and Wales had excess mortality of 23,500 during the winter of Dec 2003- March 2004. There is debate as to the relative influence of external and internal temperatures on mortality, but both appear to be significant and housing conditions are a contributory factor to the high excess mortality
- 11.4. Householders reduce energy costs once their ideal comfort zone has been reached, but improvements and standards in housing energy efficiency is based generally on lower levels of comfort than required by the occupant. The energy efficiency temperature is 19c where 80% of potential energy saving is realised but householders generally set thermostats well above 21c. This means many of the suspected heat or cost savings may not be achievable?
- 11.5. The design of thermostats generally calibrated between 10 to 30c means a bias to warmer temperatures and many thermostats are often simply used as on/off switches.

12. Ventilation Issues

12.1. We have seen that moisture build within a property is a major cause for decay and the potential development of health issues for occupants. The obvious conclusion would be;

12.1.1. Remediate the water damage issue

12.1.2. Dry out the property

12.2. The quest for tighter and more energy efficient homes has seen a general reduction in ventilation to retain the expensive warm air. The reduction in ventilation means that humidity may rise. Warm air can contain more moisture than cold air, the inference here is that the warmer a home is the more evaporation will be encouraged from wet or damp materials. We must therefore be prepared to encourage ventilation in tight buildings or those where interstitial or surface condensation occurs

13. Identifying issues

13.1. Visible mould growth is a good indicator that you have a WDB. Small areas of mould around a shower tray, edge of a bath or even slight growth around a window is almost normal and can be simply be removed by normal cleaning methods.

13.2. If mould is hidden in cavities you may sometimes smell its earthy odour although not all mould release the tell-tale odour.

13.3. Unexplained health issues following a water damage event may be a good indicator that investigation may be necessary, especially if visible signs of mould growth are absent.

13.4. Visible markers of water damage such as staining, swelling and cracking of decorative finishes is another good indicator.

13.5. Where visible mould is present little further investigation is required except identifying the moisture source, how to remediate and remove the mould.

13.6. Condensation on windows is a clear marker that moisture is trapped within the building and that ventilation rates or heating regimes are inadequate

13.7. Efflorescence and bubbling of finishes on plaster or brickwork are indicators of high moisture content

13.8. Swelling and cracking to wood skirting, joints and wallpaper separating at seams

14. Conclusion During the life of a structure, it would be optimistic in the extreme to expect there to be no instances of the fabric getting wet. It is essential that once the cause of

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