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Moisture status in municipal buildings

Anders Kumlin, M.Sc. [1]
Ingrid Johansson, M.Sc. [1]
Dan Norbäck, Associate professor [2]
Gui-Hong Cai, Ph.D. [2]

[1] AK-Konsult Indoor Air AB, Stockholm, Sweden
[2] Dept. of Medical Science, Occupational and Environmental Medicine, Uppsala University, Uppsala, Sweden

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SUMMARY:
An ocular inventory, e.g. identifying risk constructions and damages, by trained moisture consultants is a good method to get information on dampness status of all municipal buildings within one area. A significant association between levels of total Fungal DNA on indoor surfaces and risk construction grading of the buildings confirms that risk construction may lead to increased indoor mould contamination.

1. Introduction

Moisture in buildings, also called damp buildings or building dampness, is a common problem in many countries (WHO 2009). If the moisture level is increased in buildings, it may lead to growth of mould and bacteria (microbial growth) as well as chemical degradation of certain building materials. One well known problem in Sweden is alkaline degradation of water based adhesive in floor-constructions, or plasticizers in PVC materials, causing emissions of butanols and 2-ethyl-1-hexanol (Wieslander et al., 1999; Norbäck et al., 2000). A number of epidemiological studies have demonstrated that buildings with increased levels of moisture and microbial growth can lead to impaired health, with increased occurrence of asthma, asthma symptoms, respiratory infections and symptoms included in the sick building syndrome (e.g. eye and nose symptoms, headache and tiredness) (WHO, 2009). Some studies from Sweden have indicated that increased levels of moisture in the floor construction, causing degradation of water based adhesive or plasticizers in the floor, is associated with increased nasal inflammation (Wieslander et al., 1999) and asthma (Norbäck et al., 1999; Norbäck et al., 2000).

Moisture in buildings can occur for different reasons. Buildings can have water leakages. Moreover, buildings with high humidity production indoors combined with poor ventilation and temperature differences on indoor surfaces can lead to surface water condensation. This condensation may lead to microbial growth on indoor surfaces that can be observed. Visible mould growth on indoor surfaces is a relatively common problem in a warmer climate zones in Europe (Norbäck et al., 2013). However in a colder climate, such as in Scandinavia, increased moisture levels in buildings can occur inside wall, floor or roof-constructions without any visible signs of dampness or microbial growth (hidden moisture).

The concept of risk construction, e.g. risk construction due to moisture, has been used in Sweden to describe a building where the building construction leads to an increased number of buildings with moisture related problems. In Sweden, the focus has been on risk constructions related to type of floor construction. The home is the indoor environment where we spend most of our time, and most studies on health effects of building dampness and indoor mould growth have been performed in dwellings (WHO, 2009). However, indoor problems are often reported in public buildings such as schools (Simoni et al., 2011) and day care centres (Bröms et al., 2006). In such cases, when indoor problems occur in a particular building, moisture consultants are often contacted to perform an investigation and suggest measures to solve the moisture related problem. However, there are few surveys investigating the prevalence of risk construction and moisture in all types of public buildings within a defined geographical area (e.g. one municipality).

The aim of this study was to survey municipal buildings in four municipalities in the Stockholm area for moisture status and risk for moisture problems. Moreover, this knowledge informs the property owners about moisture and risk status to be able to plan maintenance, corrective preventive actions and refurbish actions. The report sent to the property owners was kept short and was typically one page. Finally, the aim was to study the association between moisture status and risk for moisture problems and levels of indoor mould, measured as fungal DNA contamination on indoor surfaces.

2. Methods and results

2.1 Methods

Ocular inventory regarding moisture status was performed in municipal buildings in four different municipalities in the Stockholm area, mostly schools and day care centres. The inventory was an ocular inspection. Consultants performing the inventory were trained moisture consultants with long experience in investigating buildings with moisture problems. Total fungal DNA in dust from swab samples was analysed in day care centres in one of the four municipalities. Total fungal DNA is an indicator of mould contamination.

The buildings were graded according to a three level scale; low risk (level 1), risk (level 2) and damage (level 3). The levels were defined as follows: Low risk (1) means that no risk was associated with the building construction (a non-risk construction) and moreover no visible indoor mould, mould odour or visible moisture damage was observed. Risk (leve1 2) means that a risk was associated with the building construction (a risk construction) but no visible indoor mould, mould odour or visible moisture damage was observed. Damage (leve1 3) means that a risk was associated with the building construction (a risk construction) and moreover visible indoor mould, mould odour or visible moisture damage was observed.

A ground-construction that normally works well from a moisture point of view (a non-risk construction) in Swedish climate is described in fig 1. Three ground-constructions associated with a risk for moisture damage (a risk construction) in Swedish climate is described in fig 2-4. Calculations for concrete slabs have been done with assumed temperatures in the ground, annual mean 7°C, and known material moisture and heat resistant’s. The crawl-space is simulated with the computer program CrawlRF.

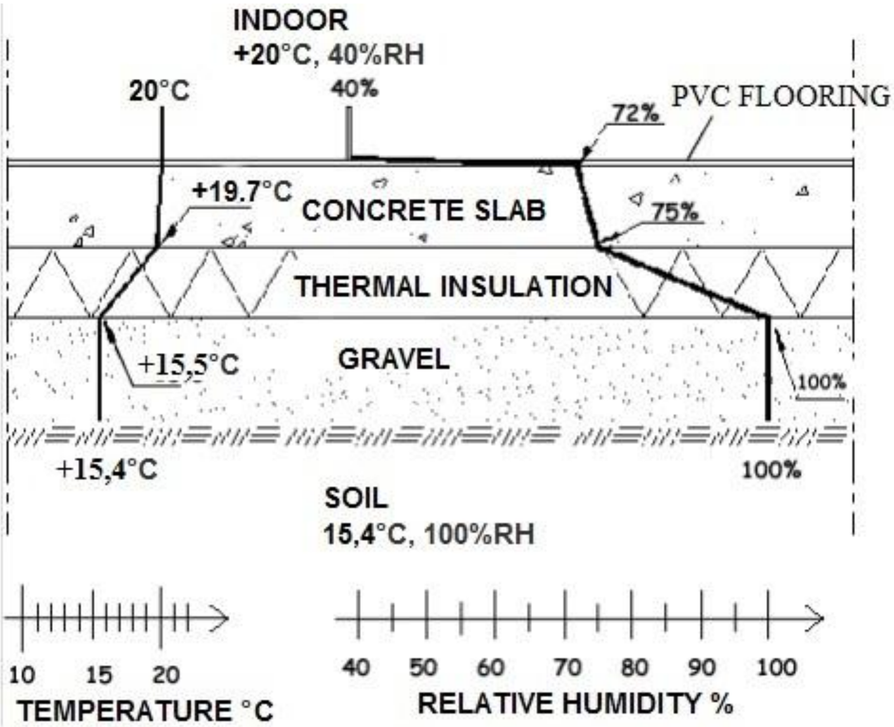

FIG 1. Expected humidity levels in a concrete slab with underlying thermal insulation

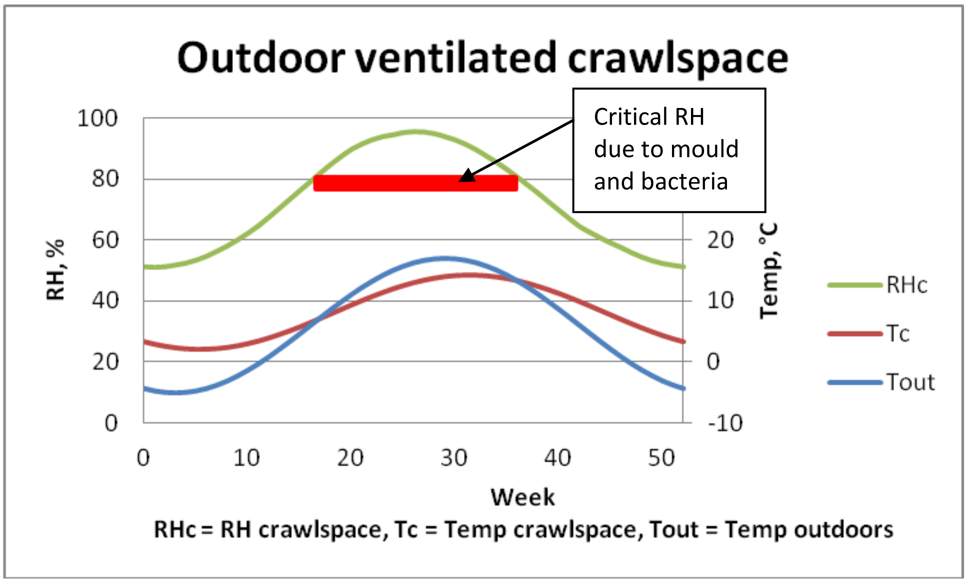

FIG 2. Expected humidity levels in an outdoor ventilated crawl space

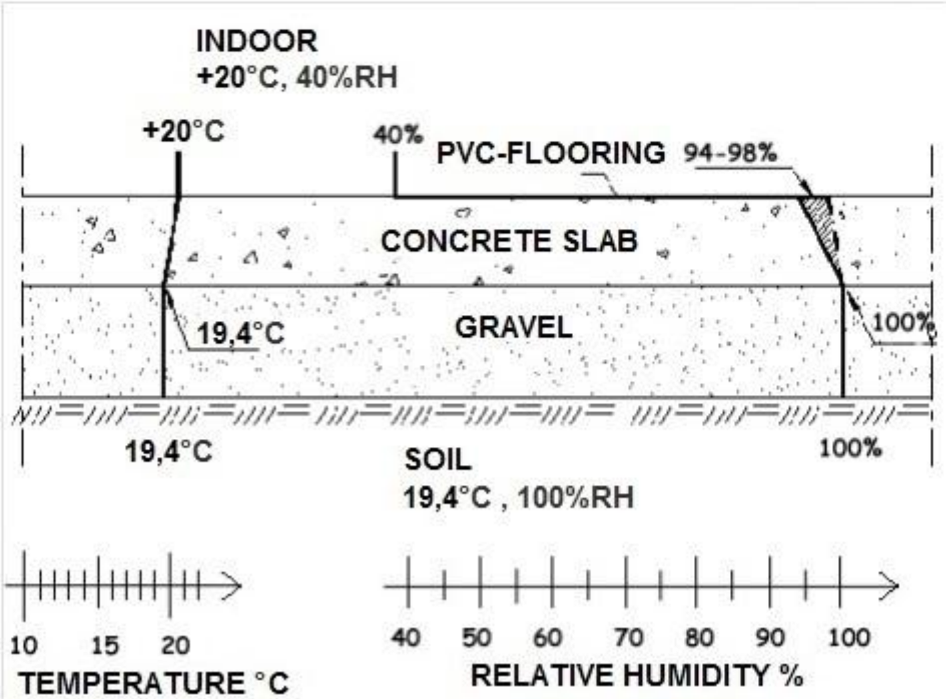

FIG 3. Expected humidity levels in a concrete slab with PVC flooring and no moisture barrier or thermal insulation under the slab

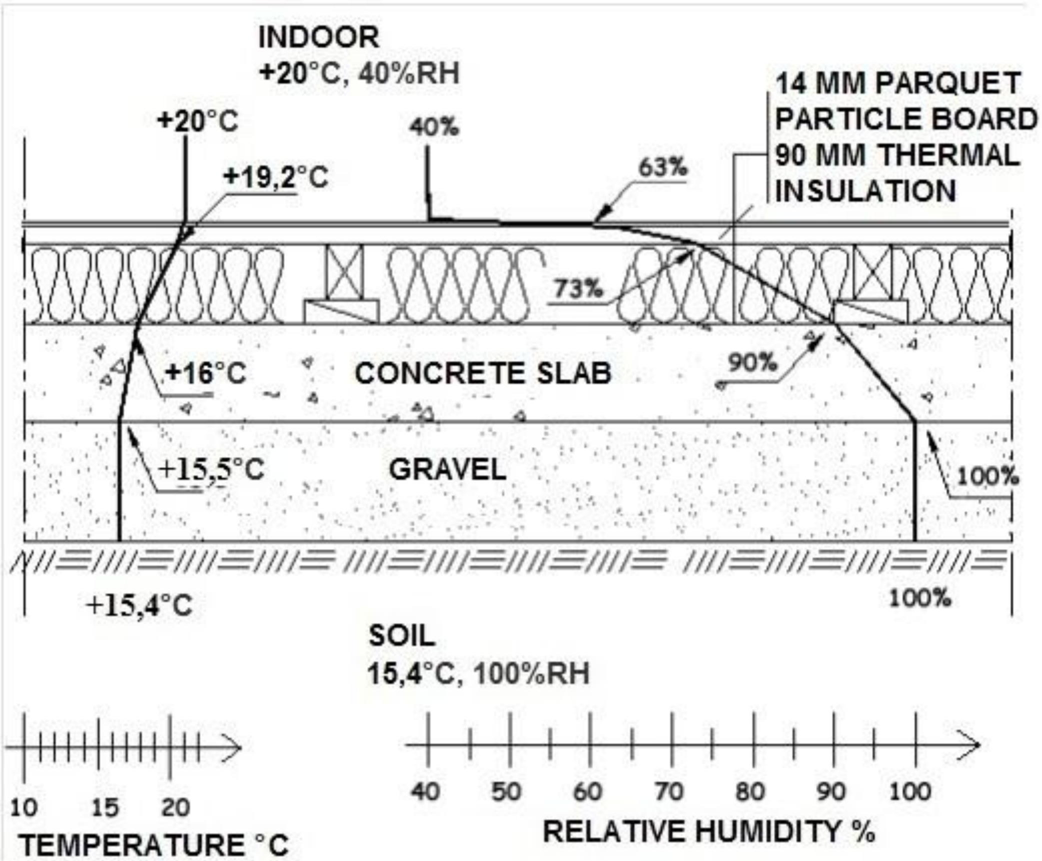

FIG 4. Expected humidity levels in a concrete slab with overlying thermal insulation

Dust sampling for fungal DNA analysis was performed in one municipality in the north east part of Stockholm. In total 24 day care centres were identified. Three of the day care centres were excluded in this study since they were located in school buildings, and could be influenced by the school environment. Dust collection was performed in the remaining 21 day care centres (26 separate buildings). Surface dust was collected in 3-5 randomly selected rooms in each building. The number of rooms depended on the size of the buildings. Dust was collected by swabbing a 60 cm^2 surface (1×60 cm) of half of the upper part of the doorframe on the main entrance door to each room with a sterile cotton swab. If the main entrance door had a supply or exhaust ventilation duct above the doorframe, another doorframe without any ventilation duct was selected. Two samples were collected by dividing the doorframe into a left and a right side, and the left-side swab was used in this study. Fungal DNA was analysed by quantitative PCR (QPCR) by a previously described method (Cai et al., 2009; Cai et al., 2011). A fungal DNA sequence common for a large number of moulds (Universal Fungal assay 1) was analyzed, here described as total fungal DNA. The mould species detected by this total DNA method is available online at http://www.freepatentsonline.com/6387652.html. The mould level was expressed as cell equivalents (CE) assuming one copy per cell. The final results were presented as CE/m^2 of swabbed surface area. Data on total fungal DNA was log-transformed to get an approximately normally distributed variable. Associations between building factors and total fungal DNA were analysed by linear mixed models, to adjust for the hierarchic structure of the data (room and building level). A p-value below 0.05 was considered significant.

2.2 Results

Totally 316 buildings were investigated. In total, 53 buildings (17%) were rated with grade 1, 135 buildings (43%) with grade 2 and 128 buildings (41%) with grade 3. Among the 26 day care centre buildings where dust was collected for fungal DNA analysis, 4 buildings (15%) were rated with grade 1, 8 (31%) with grade 2 and 14 (54%) with grade 3. Among the rooms (N=103) in the 26 day care centre buildings, 13 rooms (15%) were in buildings rated with grade 1, 31 rooms (31%) in buildings with grade 2 and 59 rooms (54%) in buildings with grade 3.

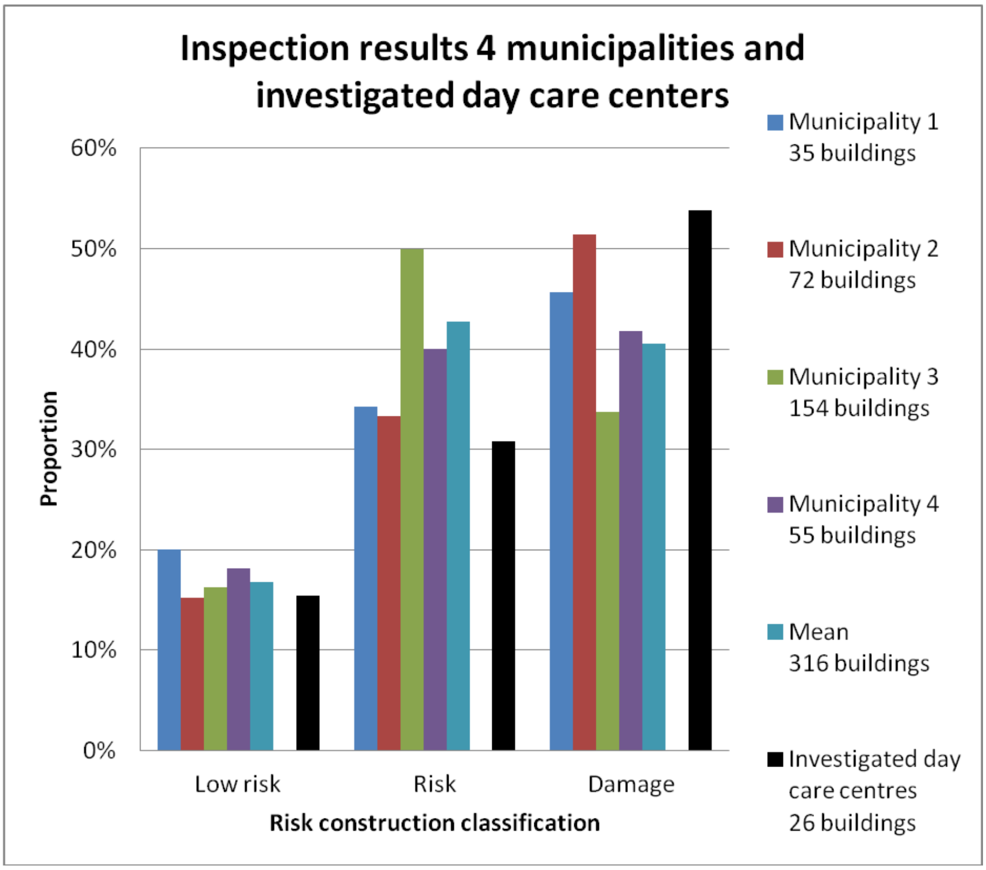

FIG 5.Inspection results in total

There were associations between total fungal DNA in swab samples and risk construction classification, rotating heat exchanger and linoleum floor material. The geometric mean (GM) of total fungal DNA was $3.0*10^6$ among rooms in buildings with risk level 1, $3.7*10^6$ among rooms with risk level 2 and $4.9*10^6$ among rooms with risk level 3 ($p<0.05$ for trend). Moreover, the GM of total fungal DNA was 2.1 times higher in rooms in buildings with linoleum floors as compared to PVC floors ($p<0.05$) and 1.5 times higher in buildings with a rotating heat exchanger ($p<0.05$). The associations between fungal DNA levels and risk construction classification remained significant even after adjusting for type of floor and rotating heat exchanger.

3. Conclusions

An ocular inventory by trained moisture consultants is a good method to get information on dampness status of all municipal buildings within one area. A dampness survey of all buildings within one area, e.g. one municipality, is important in terms of dampness prevention since it identifies building that are in most need for refurbish action. This is particularly important since many of the municipal buildings are schools and day care centres, important indoor environments for children. Adequate prevention measures may also lead to health improvements in the population. Finally the significant association between levels of total Fungal DNA on indoor surfaces and risk construction grading of the buildings confirms that risk construction may lead to increased indoor mould contamination.

4. Acknowledgments

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