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Moisture supply in Danish single-family houses – the influence of building style

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Abstract

According to ISO 13788 internal moisture supply in dwellings can be described by humidity classes defined by outdoor temperature, occupancy and ventilation. Hygrothermal measurements in 500 Danish single-family houses were made to investigate if building style and geographical location are important as well. Further it was investigated whether snapshot measurements in materials could replace logging of relative humidity and temperature. Building type has only a limited effect on the moisture supply. Geographical location has an effect; however variations are not systematic. It is not possible by means of two-pin or capacitive moisture meter measurements to estimate indoor relative humidity.

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Keywords: Building style; capacitive moisture meter; dwellings; geography; humidity class; hygrothermal sensor; moisture supply; two-pin moisture meter

1. Introduction

Since 1995, the seller of a house in Denmark can be insured against claims from the buyer by requesting an offer for insurance, based on an inspection documented in a Home Condition Report (HCR) made by a building expert [1]. The HCR should lay out the condition of the house compared to what can be expected from a house of similar type and age with a typical/normal level of maintenance. The building inspection is visual with the option of using simple hand-held instruments, if relevant, but with no destructive measures allowed. It has been discussed to let the inspection

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include a snapshot of the moisture conditions to indicate whether a specific house has an increased level of moisture compared to what is "acceptable" [2].

Knowledge on when mold growth happens at non-stationary conditions is lacking and it is very individual at what level people's health is affected. The acceptable level could therefore be based on a combination of what is normal for Danish dwellings and at what conditions mold growth is expected to take place. However, statistical based knowledge on what is a normal moisture level in Danish houses does not exist.

Measurements were performed in 508 Danish mainly owner occupied single-family houses at different time of year to test if humidity class 2 according to [3] represents normal level of moisture. Humidity classes are based on interrelated values of *moisture excess* – difference between outdoor and indoor moisture content expressed in g/m^3 – named *moisture supply* in this paper, and outdoor temperature, depending on the use of buildings. The hypothesis in this paper is that moisture conditions in houses depend on building style including design of building element, i.e. the layer structure, materials included etc., not considered by [3]. Influence of occupant behavior is the subject of another paper presented at the conference [4]. Further details concerning the study are described in [5].

2. Research method

Moisture supply in a house is determined by moisture production and ventilation rate, both regarded as being mainly dependent on occupant behavior, but may also be caused by the house itself. As the moisture production may be affected by the choice of building materials and building style. Similarly, the ventilation rate will be dependent on air tightness of the house and type of ventilation, mechanical or natural. Occupant behavior is difficult to distinguish from the influence of the house itself, unless a study includes many houses of a specific building style, which is the case in this study on Danish single-family houses.

Based on changes in building style and use of building materials seven building types were defined, consisting of two types representing the period before 1910 – with and without timber framing – and four types after, one of these covering wooden houses. Summer cottages are treated as a separate type, no matter the type of materials used, as these are not occupied full time. Although in the Danish building stock the number of houses per type are not the same it was decided in the study to select the same amount of houses of each type, as building types with few houses (timber framing and summer cottages) varies quite a lot in style, while a more common building type (houses built 1960-1979) are relatively homogeneous. Selection of houses and type of information collected is described in [4]. To cover seasonal variations the investigation was spread out over a whole year.

It is possible to measure moisture content in the air of a building during a short visit, but the value may change fast, e.g. if the room is aired. Materials on the other hand react slowly; measurements of moisture content in materials although being a snapshot may give a good picture of the moisture content level. To cover both snapshot measurements and measurements for a longer period ensuring a more detailed picture of the moisture conditions, the following instruments were used to assess the moisture conditions:

- *Hygrothermal sensors* logging indoor climate (temperature and relative humidity) two times per hour for 14 days (EL-USB 2+ from Lascar). In each hose 3-5 sensors were placed, typically in bathrooms, living rooms and bedrooms, i.e. not all rooms in all houses are included in the study. An extra sensor was placed outside.
- A moisture meter working as a *two-pin moisture meter* in wooden constructions and *capacitive moisture meter* at mineral based materials (MO290 from Extech Instruments).

3. Results

3.1. Measurements of indoor climate (temperature and relative humidity) with hygrothermal sensors

Measurements of temperature and relative humidity (RH) were converted into moisture content (g/m^3) in the air for both indoor and outdoor measurements. For each type of building an average value for each of the rooms included in the study was calculated. Further, average values of indoor temperature, indoor relative humidity and moisture supply for each room and for each house as a whole were calculated. Figure 1a shows the distribution of average moisture supply for each room where a sensor was placed (in total about 1600 rooms in 500 houses). The typical average moisture supply lies between 0 and 2.5 g/m^3.