Building and Environment 56 (2012) 1–7

Contents lists available at SciVerse ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Air Gap Method: Dependence of water removal on *RH* in room and height of floor air gap

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ARTICLE INFO

Article history:
Received 8 December 2011
Received in revised form
26 January 2012
Accepted 11 February 2012

Keywords:
Ventilated cavity
Air gap
Heating cable
Water damage
Air flow
Relative humidity

ABSTRACT

Using the Air Gap Method inside building constructions, harmful water can be dried out. The method ventilates air gaps inside walls and floors with an air flow driven by convection aided by a heating cable in the vertical air gap.

This study is performed in combined floor and wall constructions with air gaps within and with a heating cable in the vertical air gap. All surfaces of the air gap are covered with polystyrene plastic to avoid leakage into the construction. Wet gypsum boards that are weighed at start and end of experiment are used to measure the dry out process.

Three different heights of the floor air gap, 25 mm, 15 mm and 5 mm are investigated. The influences of the *RH* in the surrounding room and of the wetness of the gypsum boards are also investigated.

It is shown that the height of the floor air gap has a great impact on the rate of drying. The optimal height is less than 25 mm and somewhere between 15 and 5 mm.

1. Introduction

Sick building syndrome is a combination of illnesses, associated with buildings and a majority of the sick building syndrome is related to poor indoor quality. The causes could be among others, bad ventilation, dry air and emissions from material and mould. The Air Gap Method dries out harmful water from the construction, thus reducing growth of mould.

1.1. Water damage and building construction

Water damage and mould are linked to allergic reactions among children [1]. When water and mould-damaged houses are remedied, the users' health is found to improve [2]. In the case of water damage the relative humidity (*RH*) of the construction air (by which we mean the air enclosed within walls and intermediate floors) may come close to 100% *RH*. Mould needs a satisfactory temperature, sufficient time and at least 75% *RH* to grow. When the humidity rises, the growth of the mould becomes more rapid [3]. To remove dampness, air gaps should be introduced into the building structure to make ventilation possible.

1.2. Building methods

Although building science has paid very little attention to the problem of low ventilation inside building constructions, at least three well-established building methods consider the problem, the floor on joists (the Nivell floor), the ventilating plastic membrane and the ventilated prefabricated bathroom (the Viab method).

The Nivell floor is built on joists attached to the structural slabs of the building and an air gap is thus created below the insulation (www.nivellsystem.com). The floor system itself is rather cheap to build and gives the physical preconditions for ventilation of the construction air. This ventilation should be forced by mechanical appliances which are, however, rather expensive and require service.

The ventilating plastic membrane is provided by a number of manufacturers (www.isola-platon.se) and (www.floordry.se). The membrane creates an air gap of about 5 mm above the water damaged floor and gives the physical preconditions for ventilation of the construction air, which must be driven by mechanical appliances. The ventilation rate in this type of system has been investigated by Hagentoft and Holmberg (2005) [4].

The Viab method is used to build prefabricated bathrooms which are installed inside an old bathroom, possibly also with water damage (www.rumirum.se). An air gap through which ventilating air can circulate separates the new bathroom from the

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doi:10.1016/j.buildenv.2012.02.014

old structure. This method relies on natural ventilation and facilitates the removal of, for instance, construction damp which can escape after the prefabricated bathroom has been installed. As this method creates an air gap in both walls and floor it resembles the Air Gap Method described below.

1.3. The Air Gap Method

The Air Gap Method is a modification of the common way of producing houses with infill wall constructions. It is built with the same materials, by the same techniques, but by the Air Gap Method makes ventilation flow possible through the whole construction in a cost efficient way. The method permits convective air flow inside the construction. The aim of the method is to remove dampness from the construction and thus protect it from moisture related damage such as mould. The air enters by the inlet, passes through established or existing air gaps in floor and walls and exits by the outlet. The air flow is driven by a heating cable situated in the air gap in the lower part of the wall.

In the renovation of a water damaged house, the Air Gap Method makes it possible to dry out dampness without a separate drying period, which is often as long as 6–8 weeks. The residents could therefore return to the building earlier than when traditional renovation concepts are adopted. The method is also useful for making houses more robust towards such damages.

1.3.1. Former results

The ability of the Air Gap method to dry out water damaged floor constructions has been described by af Klintberg, Björk and Johannesson (2007) [5]. When a floor construction with an area of 24 m^2 was flooded with 120 L of water; most of the water was drained out immediately and the remaining water was ventilated by the air gaps. The study showed that a flooded construction was found to become dry in 11–12 days without any trace of mould growth. The drying out process was faster when one heating cable was switched on and even faster with two heating cables.

The study of af Klintberg and Björk 2010 [6] also showed how the Air Gap Method reduced the relative humidity inside a ground floor construction and that the humidity was transported through the air gaps in the floor and wall. These studies involve full-scale experiments which had certain shortcomings. It is difficult to repeat the experiments, as the drainage and the *RH* of the surrounding air differ significantly from test to test.

2. Aim of this study

Since earlier results [5–7] show that the Air Gap Method seems to work in a full-scale situation, this study was undertaken to investigate how the drying capacity in a construction according to the Air Gap Method is influenced by the height of the air gap and by the *RH* in the room. A considerable number of repeated tests were carried out but only a limited number of influencing parameters were changed.

3. Test equipment

The tests have been carried out in test rigs with air gaps to which heat has been supplied using a heating cable.

3.1. Design of the test rig

The test rigs are L-shaped elements, see Fig. 1, which are built to model floor and wall components put together, as shown in Fig. 2. The test rig contains an air gap that runs through both floor and wall components with a heating cable placed low down in the vertical air gap. The experiment deals with the drying of wet parts and it is important that as little water as possible leak out into the structure of the test rig or through joints. All the inner surfaces and joints in the horizontal part of the test rig were sealed with a barrier of a 2-component plastic resin to hinder any loss of dampness. This is marked as the “moisture barrier” in Fig. 2. All the joints were sealed with rubber weather-strips; see position 10 in Fig. 2. For the study, six test rigs were built.

Fig. 1. The figure shows five of the six L-shaped test rigs, here open with the moistened gypsum boards inside. The arrow points to the heating cable T-18.

The design of the test rig is shown in the cross-section shown in Fig. 2; the materials are also indicated in this figure. The horizontal construction was mounted on a wooden framework of 45 × 145 mm studs. This part was 1.4 m long, 0.3 m wide and 0.18 m high. The air gap in the horizontal region was 25 mm high in two of the test rigs, A and B. In the next two rigs a 10 mm thick plastic treated MDF-board was introduced so that the air gap was 15 mm high, in test rigs C and D and in the last two rigs two layers of MDF-board were introduced so that the air gap was only 5 mm high in test rigs E and F. The moistened gypsum board placed in the horizontal part (position 11 in Fig. 2) was divided into two halves, to make it easier to handle; each piece measured 200 × 700 mm. The vertical part of the test rig was mounted on a wooden frame of 45 × 70 mm studs. This part was 2.0 m high, 0.30 m wide and 0.10 m deep all together.

3.2. Heating cable

The temperature in the vertical air gap is raised by a heating cable attached to the bottom sill (position 8 in Fig. 2). This heating cable, denoted T-18 is manufactured by Ebeco AB and the intended use of the cable is to melt ice inside drain pipes. It is made of two electrical conductors embedded in a semiconductor material whose resistivity increases with temperature, so that the maximum temperature lies in the range of 28–40 °C.