Humid Wall: Review on Causes and Solutions

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ABSTRACT

Due to having airtight buildings, humid or wet walls have become a common problem in the last decades. Some common consequences of having humid walls is the growth of mold, which has a bad impact on the health and the comfort level of the internal environment. There is evidence that the effect of humidity on health is strong. Furthermore, the moisture content of the wall has a direct impact on its thermal resistance. This is due to the increase of thermal conductivity value of the wall. Briefly, the humid wall problem has a direct consequence on both energy consumption of the heating system and the health of the occupants. Hence, preventing and fixing humid wall problem is a challenge that is worth a closer investigation.

Humid walls can be a result of an external reason; namely external moisture enters the building through the envelope of the building. Alternatively, the moisture that comes from cooking, bathing, washing, and people can constitute an internal cause of humid walls in buildings with poor ventilation system and low insulation level. The current paper studies the causes of humid walls and the possible solutions. Comparisons between different solutions are made.

Keywords: *humid wall, drying process, wall treatment, thermal resistance*

1. INTRODUCTION

Sustainable design of building concentrate mainly on three area including (Karagiozis, Salonvaara, 2001): 1) energy performance, 2) environmental impact, and 3) inhabitants' safety and health. Exclusively dealing with these critical areas might lead to make the interior environment more isolated from the exterior environment. This results in increasing the indoor relative humidity and, consequently, more ventilation rats are needed. In many cold humid climates, due to having airtight buildings, humid or wet wall became a common and serious problem in the last years (Hens et al., 2007, Vos, Tammes, 1978, Newman et al., 1982b, Newman et al., 1982a). In 1970s, for instance, buildings were constructed and retrofitted to reduce energy consumption. Definitely, these measures made the building more energy efficiency of the buildings improved. However, this approach created problems in respect to stability of the building envelope as moisture accumulation in the building structure (Tariku et al., 2010). In addition, moisture problems are the cause of significant economic costs from both repairs and health of the occupants' perspective (Burke, 2009).

Building envelope, both above and below the grade, plays a role in determining the amount of moisture gain or loss that the building and its mechanical system has to dealt with. Moisture can enter the wall through capillary and small cracks in the concrete rendering and becomes trapped in the construction (Van Belleghem et al., 2015, Barrett, 1998). Buildings in most cases are very tight. This means that in a house with a poor ventilation system, the moisture that is released into the indoor air from cooking, bathing, washing, and people has no other way to escape the house, which might cause condensation on the cooler surfaces. In addition, the moisture can enter the buildings through capillary action. The latter occurs where the water travels through the walls through small pore spaces or small cracks in the concrete and becomes trapped. Some common consequences of having humid wall is mold growing, which has a bad impact on the health and the comfortable level of the internal environment. There is evidence that the relationship between the humid and health is strong since the humid in buildings appears to increase the risk of cough, respiratory illness, wheeze, and asthma (Bornehag et al., 2004).

On the other side, the moisture content of the wall has a direct impact on the thermal resistance of the walls (Tinker et al., 1992). This is due to the increase of thermal conductivity value of the wall. In order to demonstrate the impact of the moisture on the thermal resistance of the wall, many materials have been tested in laboratory with different moisture content. As shown in Figure 1 (Veas, 2006), the moisture content affects the thermal conductivity of the

materials and, consequently, the wall thermal resistance. It is worth mentioning that at the design stage the moisture content of wall is usually assumed to be 3% at the inner side of a wall and 5% at the external side (Tinker et al., 1992). Hence, moisture content of building envelope has a significant effect on the heating load of the building. For example, assumed wall thickness is 20 cm of:

- Brick wall: Increasing the moisture content of the walls from 5% to 13% leads to reduce the thermal resistance by 25%
- Concrete wall: Increasing the moisture content of the walls from 3% to 5% leads to reduce the thermal resistance by 20%.

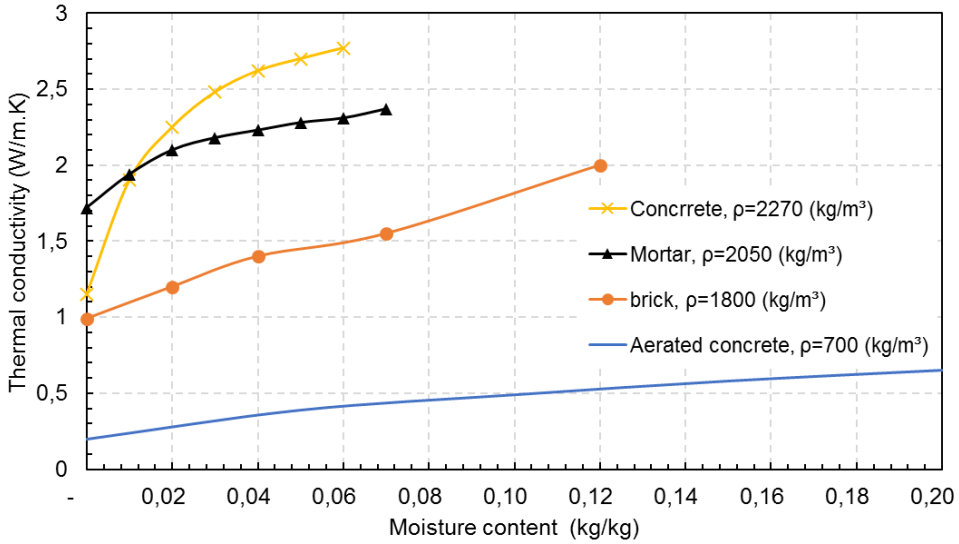

Figure 1: Relation between moisture content and thermal conductivity at temperature equals 20°C

In addition, currently there is general engorgement to refurbish a lot of buildings to match with current thermal performance standards. Yet, humid walls are a barrier to refurbishment as they increase cost of refurbishment. Accordingly, understanding humid walls problem and solutions seem to be of significant benefits for tenants' comfort, building stability, energy performance of the building, and refurbishment of such buildings. Current work, therefore, discusses the sources and the solutions of increasing wall moisture content.

2. SOURCES OF INCREASING WALL MOISTURE CONTENT

To have permeant solution of wet wall, it is very important to know where the moisture comes from. In cold climate, the common cause of humid walls is having the surface temperature lower than the dew point. The latter depends on the dry bulb temperature and the relative humidity. Hence, the internal relative humidity must be kept at a certain level that guarantees the dew point to be kept lower than the surface temperature. This can be achieved either by using dehumidifier and/ or use sufficient amount of ventilation air. In addition, installing insulation on the wall that is exposed to the external cold air can reduce the risk of having wall surface temperature lower than the dew point.

Conversely, in some cases humid wall can be a result of external reason. In such case the external moisture enters the building through the envelope of the buildings.

As depicted in Figure 2, the main moisture sources can be classified into two main categories include (Van Belleghem et al., 2015):

- External source includes precipitation, surface water/ runoff, and groundwater
- Internal source, namely high relative humidity of internal environment.

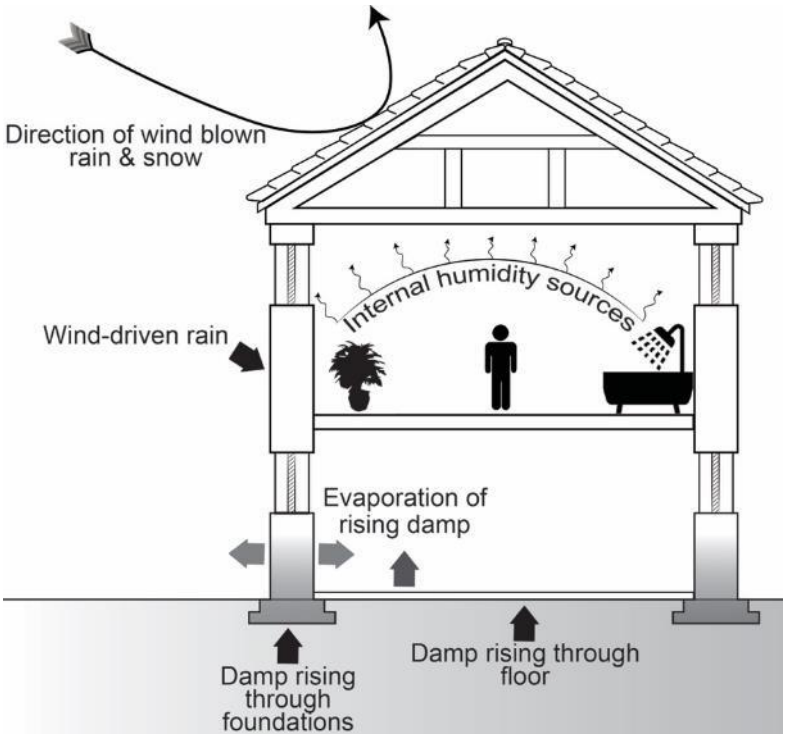

Figure 2: Sources of humid wall problem in the buildings

2.1 Internal source, i.e. the indoor humidity

Moisture released from cooking, bathing, washing, people has no way to escape the house. In the cases where the buildings have poor thermal performance, accumulation of the internal humidity causes condensation on the cooler surfaces. This is a common problem in cold climate buildings where the condensation on the warm side of exterior wall during the wintertime has a high probability for condensation. The temperature of the walls can reach the dew point due to poor insulation or higher thermal bridges (Calbureanu et al., 2010). The relation between the dew point temperatures, dry bulb temperature, and humidity of the air is illustrated in Figure 3. For instance, if the indoor temperature is 20 and the relative humidity is 70%, the condensation will occur on the walls if the temperature of the inner side become lower than 15°C.

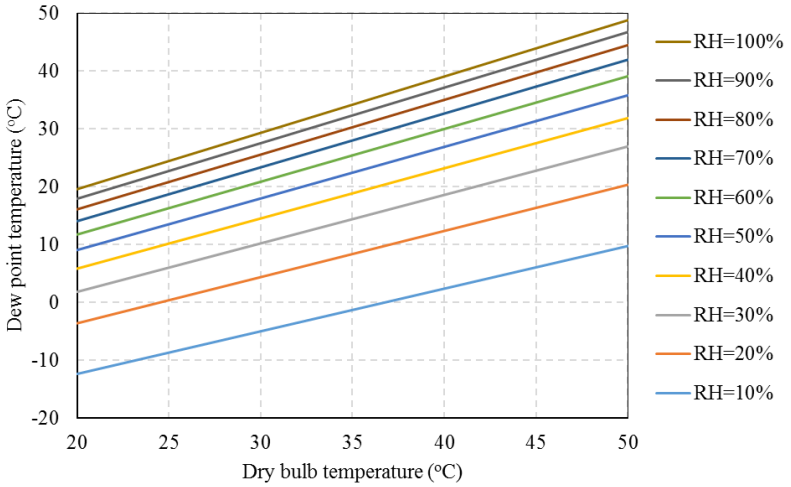

Figure 3: The dew point temperature as a function of relative humidity and dry bulb temperature

2.2 External source, e.g. rainwater

Rainwater, melting snow, or groundwater can saturate the soil around the foundation of the buildings and, consequently, leak in. As well as, the wind driven rain can penetrate the external walls due to the porosity or the cracks that exist in the wall (Van Belleghem et al., 2015, Hens et al., 2007).

2.3 Damp rising

In this case, the moisture is leaking vertically into the building. If the surrounding ground has a high level of the moisture, water will rise by capillary action through the pores and evaporate internally. Consequently, salts crystal is formed on the internal surface of the walls. Hence, even if a solution that prevents ground water to enter the building was applied, the salts on the wall will continue to absorb mustier from the surrounding indoor environment and, consequently, the wall remains wet (Damp proofing, 2016).

3. DIAGNOSE

It is often difficult to detect the cause of wet walls problems in buildings. However, the easiest way to find out the source of the problem is using a large sheet of aluminum foil to be taped to the considered wall and inspect it few days later. Moisture behind the foil indicates moisture is leaking from outside through the walls. While, moisture on the outside surface of the foil means high indoor humidity.

Alternatively, using moisture meter and moisture content of the wall at different depth in the wall. Two cases can be distinguished:

- The moisture content increase with the depth (from inside toward outside): this indicates that the source of humidity is external.
- The moisture content decreases with the depth (from inside toward outside): this indicates that the source of humidity is internal.

4. WALL DRYING OUT METHODS

The speed of drying is largely dependent on (Kidd et al., 2010): 1) drying method, and 2) wall materials. Three methods are commonly used to dry out the wall:

- Heat-based methods: Using heat and ventilation,
- Dehumidifier: Using heat pump to absorb the humidity from the indoor space,
- Chemical-based method: Using chemical agent, such as Sodium hydroxide, to absorb the humidity from the indoor space.

4.1 Heat-based method

In the heat-based method, a lot of heating and air moving system is needed. Hot and drying are with temperature above 40°C must be supplied to the treated space for 2-3 days. By using such method, there is still some doubt as to the possibility of damage to building contents. Therefore, it is important not to over-dry; this wastes energy and time and increases the risk of damage to building components. Therefore, monitoring the drying process is necessary for two main reasons: enables better control of the environment and allows the perfect drying chamber to be maintained more easily. Monitoring is also used to signal the end of the drying process and consequently, save energy and time and saving building components.

Heat-based method can be applied in two different forms:

- Conventional heating method, by supply the hot and dry air to the whole indoor space. The main advantage of this method is that it is easy to install. However, in such method lot of energy and takes longer time when compared to the modified heating method.
- Modified heating method. By installing a plastic sheet close to the treated wall and then supply the drying air (or sucking the air) directly to (from) the space between the wet wall and the plastic sheet, see Figure 4. This method is fast and less energy consumed.

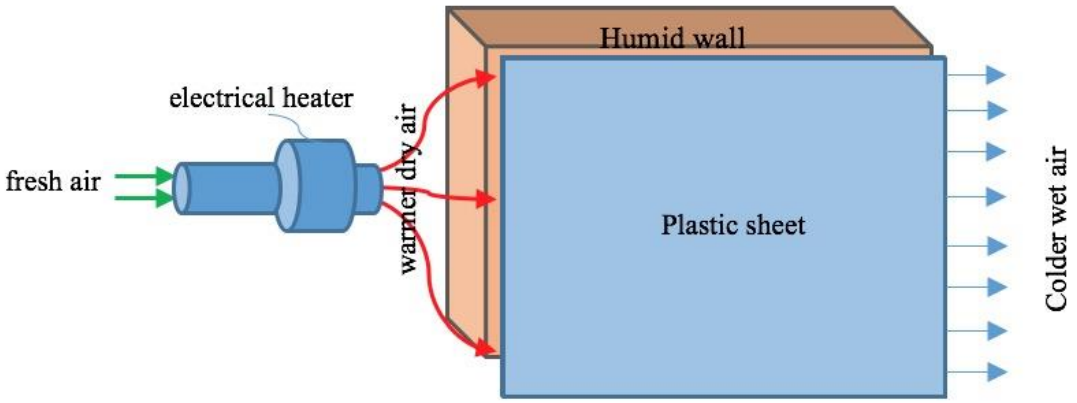

Figure 4: Modified heating method. The drying air pumped in the space between the wall and the plastic sheet

In the case where there is insulation into the wall, tiny holes can be drilled into the wall to be used to inject hot and dry air, see Figure 5

Figure 5: Drying wet wall with presence of insulation

4.2 Dehumidifier

Dehumidifier can be a useful machine to dry out the wall in a closed environment as they rely on creating an unnaturally However, dehumanization process creates a lower vapor pressure condition on the inside of the building than those on the outside so the moisture on the outside of the structure can move into the building. In another word, without a proper building envelope structure, using dehumidifier to dry out the walls engorges moisture moves though the envelope much faster.

The speed of drying is largely dependent on the capacity of the equipment relative to the space to be dried.

- Longer time is need when compared to heat-based method
- Dehumidifier should only be used, if the envelope structure is good. Otherwise, moisture might move through the envelope much faster.

4.3 Chemical base method

In chemical base method, a hygroscopic substance is needed as a drying agent to attract and hold water molecules from the surrounding indoor environment. For this purpose, various draying agents can be used include:

- Sodium hydroxide
- Silica gel
- Calcium chloride.

The drying agent can be placed in the treated space for some days. The drying agent will absorb the humidity from the pace and, consequently, the moisture form the wall will be released into the space. Alternatively, the drying agent can be applied directly to the wet wall by means of installing assistant plastic or wooden plate that is few centimeters far from the treated wall. Then, the drying agent is used to fill the space between the wet wall and the assistant wall. Compared to other methods, chemical-based method does not require energy and drying time is much longer.

5. PREVENT HUMID WALLS PROBLEM OVER AGAIN

In order to prevent the mustier wall problem occurs again, there are some procedures must be taken. The nature of the procedures depends on the source of the humid as flowing:

5.3 Externally source of the humidity

In the case where the humidity source is externally, the wall needs to be treated carefully as follow. Plug holes and cracks in the foundation. Although, holes and cracks in the external envelope let moisture and water leak into the building, patching them perhaps not solve leakage problem. However, plugging the cracks can help to minimize the problem size. Since hydraulic cement can be used under water and swells, such cement works perfectly to seal the hole and lock the plug. It should be noticed that the hole or crack must be enlarge into an inverted “V” with the narrow part of the “V” on the surface of the wall this trick assures that the cement will not be pushed out due to its expansion.

In addition, use waterproofing paint which fills the pores in the concrete or masonry walls seems to be a good method to prevent water from leaking in. to make this method is more effective, the coatings need be applied to bare walls and adding a second coat after the first dries. This guarantees to fill every pinhole and create a continuous waterproofing membrane.

5.4 Internally source of the humidity

If the source of the humid is internally, the wall needs to be insulated carefully. This way will prevent the temperature of the walls to be as low as condensation temperature of the humidity, or what so-called dew point. As mentioned above, dew point depends on the relative humidity and the dry bulb temperature of the air, as shown in Figure 3. The higher relative humidity, the higher dew point will be and, consequently, the possibility of condensing the humidity on the walls will increase. Therefore, ventilation control becomes even more important to removing excess moisture in the air, moisture that is attributed to building materials, people sweating, showering, cooking foods, etc.

It is worth mentioning that the moisture is moving through the envelope structure into the building in summer, while leaving the buildings in the winter. Accordingly, using vapor barriers is a critical issue because it might really create quite significant and problematic conditions depending on where the vapor barrier is placed. In cold climate, where moisture condenses on the inside cold wall during winter months, the vapor barrier must be located on the interior (the warm side of the wall).

6. CONCLUSIONS

Increasing the moisture content of the buildings envelope has significant impact of the energy performance of the building, the on the health and the comfort level of the occupants, and the stability of the building envelope. Current work discusses the sources and the solutions of increasing wall moisture content. In order to get rid of increasing wall moisture content permanently, it is highly recommended to detect the source of the problem. It was shown that there are three main reason to increase moisture content of the buildings envelope:

- Internal reason due to increasing the indoor humidity,
- External reason due to exterior walls exposure to harsh-climate conditions.

A comparison between three drying methods (including heat-based, dehumidifier and chemical-based) was presented. As listed in Table 1, if speed of drying is the overriding consideration then the heat-based with powerful seems to be the proper method. However, there is still some doubt as to the possibility of damage to building contents. On the other side, chemical-based method seems to be the cheapest option, but it requires a long time.

Method	Drying time	Energy requirements
Modified heat-based	short	Low
Conventional heat-based	Relatively short	Relatively low
Dehumidifier	Relatively long	High
Chemical-based	long	No energy

Table 1: Comparison between drying methods

After solving the problem, namely dry out the wall, there are several steps can be taken to prevent humid wall problem such as using thermal insulation on the external wall of low thermal resistance or patching cracks and holes in the walls. The selection of the steps depends on the source of the problem.

Future work will concentrate on a practical case and the implications of different drying methods.

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