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Principles for Controlling Water Vapor in Buildings

Seher GÜZELÇOBAN MAYUK
Gebze Institute of Technology (GIT)
Department of Architecture, Çayırova, Gebze, Kocaeli, Turkey
sgmayuk@gyte.edu.tr

Ömer Şükrü DENİZ
Mimar Sinan Fine Arts University (MSFAU)
Department of Architecture, Fındıklı, Beyoğlu, İstanbul, Turkey
odeniz@msgsu.edu.tr

ABSTRACT

One of the most important issue in architecture is to produce high comfort levelled buildings, which provide appropriate physical conditions to fulfill living needs. For this reason firstly, buildings should be protected from every kind of factors which may be harmful for them. Also, necessary precautions should be taken for building protection.

Buildings which have produced to fulfill various needs from past to present, are always face with various factors such as, thermal, water, water vapor, condensation, moisture, fire and noise. These factors may cause various failures in buildings or building elements, building users and also building environment. On the other hand, building failures are mostly caused by water vapor or condensation unless necessary protection precautions are taken in buildings. Indoor living quality may diminish and users may be affected in a negative way because of these factors. From this point of, controlling water vapor in buildings is a very important issue on the stage of not to face with or to reduce/remove similar building failures and negativities in buildings.

Different kinds of methods are used for controlling water vapor in buildings. In this paper, methods for this purpose are addressed in the context of principles. The principles for controlling water vapor in buildings are explained with a classification of Edward Allen (1992) and some building failures caused by water vapor or condensation are sampled.

This paper aims to raise awareness about principles and details for controlling water vapor in buildings. Also to make professionals and firms who are in building production process and people who are in using process conscious about this subject. So that, it is assumed to prevent or reduce building failures occured by water vapor factor.

KEYWORDS: Detailing Principles, Water Vapor, Water Vapor Control, Building Failures.

1 INTRODUCTION

Water vapor is defined as a colorless, odorless gas that is always presents in the air (Allen, 1992). Condensation of water vapor reveals variable failures on buildings or building elements. Condensation has also negative effects on building users, natural or artificial environment and economies of countries.

Condensation may be defined as the change in the gas status of water vapor into the liquid status, as a result of moist air is cooled below its dew point temperature, either by mixing with colder air or by contacting cold surfaces (Allen, 1992). Condensation inside a building may generally be arised from cooking, bathing, washing and the metabolic activities of building users. In addition to them, especially in a new building, condensation is shown because of wood, concrete, plaster and wall elements which are still have excess moisture.

Because of the condensation in buildings, the following variable building failures may be shown:

- Deterioration may be seen on insulation materials that are placed at walls or roofs and their function may decline because of the deterioration (Figure 1),
- Drops, water holes, staining and moulds may occur on surfaces,
- Wall coverings or roof membranes which are placed inside or outside of the building may crack, craze or become detached from their background,
- Building users may have health problems,
- Thermal loses may cause to rise energy consumption and decrease natural and artificial resources,
- More energy consumption and more energy requirements may cause in need of more budget.

In terms of preventing, reducing or removing same failures on buildings, it is important to provide controlling water vapor and to prevent condensation. Various methods are used in buildings for that purpose. In this paper, these methods are addressed in the context of principles. The principles for controlling water vapor in buildings are explained with a classification of Edward Allen (1992) and some building failures caused by water vapor or condensation are sampled.

This paper aims to raise awareness about principles and details for controlling water vapor in buildings. Also to make professionals and firms who are in building production process and people who are in using process conscious about this subject. By this way, it is assumed to prevent or reduce building failures occured by water vapor factor.

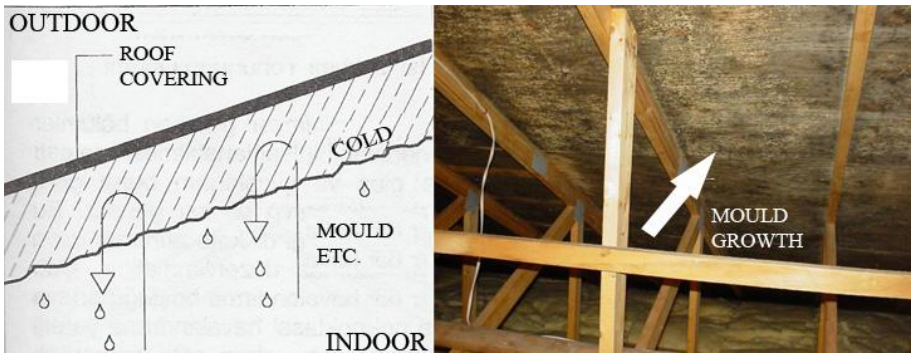

Figure 1: As a result of condensation in garret, bad mould growth and insulation materials deteriorated (Güzelçoban, 2007)

2 PRINCIPLES FOR CONTROLLING WATER VAPOR IN BUILDINGS

Such mechanical system solutions as mechanical ventilation, climatization are used for the purpose of providing indoor water vapor balance in buildings. But these types of solutions are neither natural nor economical. However, controlling water vapor in buildings may be provided by taking required precautions for water vapor in design process. For this purpose, the following main principles should be considered when designing details in buildings or building elements:

- Providing warm interior surfaces
- Using vapor retarders on warm-sides
- Providing vapor ventilation

- Providing condensation drainage (Allen, 1992).

2.1. Providing Warm Interior Surfaces

For controlling water vapor and preventing condensation in buildings, firstly, surface inside a building should be warmer than the dew point temperature of the air and be provided warm interior surfaces (Figure 2). For this purpose, internal or external thermal insulation applications are generally made in buildings. It may be provided a balance between interior and exterior temperatures and, the section of building elements and components are prevented from instant temperature changes with these type of insulations, which are applied whatever a scale of building elements or components.

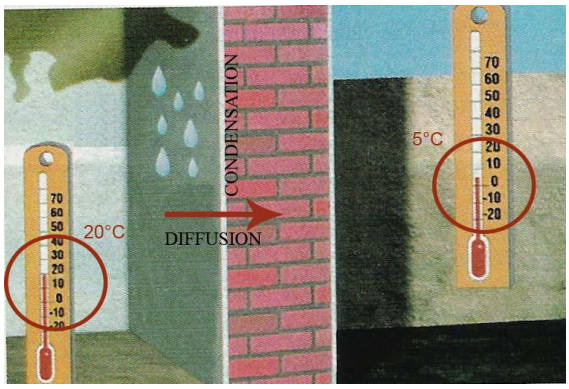

Figure 2: Condensation event on building exterior walls (Güzelçoban, 2007)

In buildings, outdoor temperatures are higher than indoor temperatures on exterior walls of spaces that are not heated inside. For this reason, condensation may be seen in wall sections. Bad mould may be growth on building surfaces because of condensation (Figure 3). In order to prevent the condensation and solve the problems caused by this factor, internal or external thermal insulation applications are made in buildings exterior walls (Figure 4). Internal thermal insulations, which externals are truer applications than internals, are useful methods for only imperative conditions like insulations on existing buildings. Thermal insulation materials in internal insulations are applied on inside surface of wall sections and vapor barriers are used over them inside of finishing surfaces. But in these applications, which are not exact solutions, it is possible to see deteriorations on thermal insulation materials and to lose their functions, because of outdoor waters that may be pass from wall spaces or condensation that may be seen in wall sections.

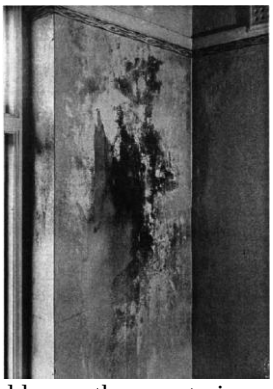

Figure 3: Bad mould growth on exterior walls interior surfaces (Ransom, 2005)

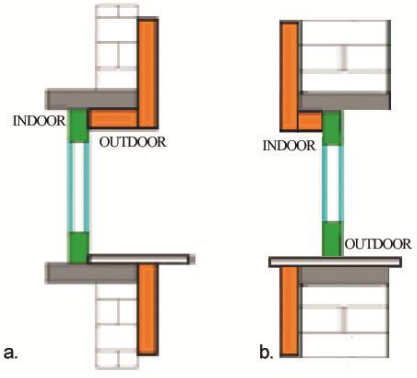

Figure 4: Thermal insulation on existing buildings exterior walls – from outside (a) or inside (b) (Web-1)

However, condensation may be shown on installation pipes or climatization systems in buildings. Because of the high interior humidity in cold water pipes and air conditioning tubes, it may especially occur on outer surfaces of them. Water drops on outer surfaces, which are occurred by condensation, may make building elements or components wet and be harmful for them (Figure 5). The outer surface of the pipe or tube is covered with thermal insulation materials, in order to prevent this type of building failures. Thus, the value of temperature on outside of thermal insulation is got closer with the temperature of room. Also, by the way of making metal foil or plastic covering on thermal insulation, water vapor on outside is prevented to pass from insulation and to condensate on pipe or tube surfaces and so, to make thermal insulation functionless (Figure 6).

Figure 5: A building failure on installation pipes or climatization systems (Güzelçoban, 2007)

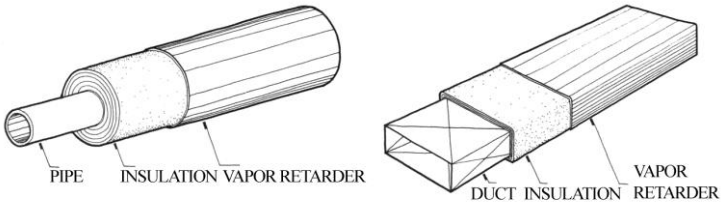

Figure 6: Insulation solutions for pipes or climatization systems (Allen, 1992)

Similarly, especially in winters, condensation may be seen on other parts of buildings like glass components. Applying thermal insulation or using double glazing may be a solution in order to provide warm interior surfaces for preventing condensation on these parts.

In addition to these solutions, there are some thermal calculation methods for determining the temperature that may cause condensation in buildings and providing a thermal balance on building elements (wall, glass or roof) surfaces. And the required details should be designed with experts according to the results of these calculation methods that may be got from building codes or various sources.

2.2 Using Vapor Retarders on Warm-Sides

Another principle to take into consideration for controlling water vapor in buildings is using vapor retarders on warm-sides.

Hot air carrys more water vapor than cold air and air stream occurs from hot air through cold air. If the temperature difference is high between hot and cold environments in buildings, condensation is seen on cold surfaces because of the instant temperature changes during water vapor transition. As a result of water vapor that condensates in these intersections, where generally insulation materials are used, and insulation materials lose their functions. Also, rots may be seen on building materials as wooden parquets (Figure 7). For the purpose of preventing such a problem, various vapor retarders should be used on warm-sides of thermal insulation materials (Figure 8). These vapor retarders may be membrane or liquid forms. It is important to choose vapor retarders that their surfaces allow air and water vapor transition in building elements where they used. Also, insulations continuity in junction points should be taken into account while applying vapor retarders.

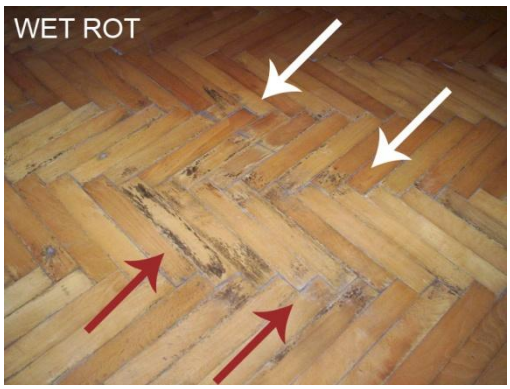

Figure 7: A wet rot on wooden parquet (Güzelçoban, 2007)

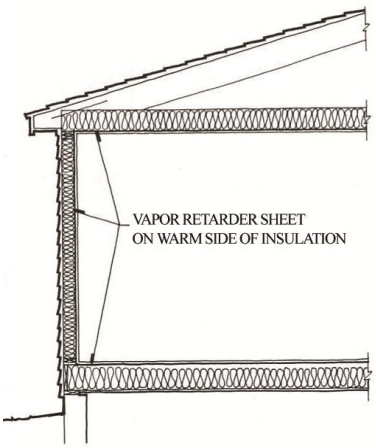

Figure 8: Using vapor retarders in wood buildings as a sample (Allen, 1992)

However, water and thermal factors are closed to each other. So, precautions for these factors should be thought about both of them. As an example, a detail solution for a roof which will be applied on cold climate condition may be arranged in two approaches as follows:

- Using vapor retarders on warm-sides,
- Arranging an air well between roof covering and thermal insulation.

In any situations like not to think about precautions on roofs, there can be seen blisters and crackings on roof coverings because of the vapor pressure. Also, thermal insulation panels and roof structure may be damaged because of water vapor, which condensates in roof section (Figure 9).

Figure 9: A building failure on thermal insulation panels on roof flooring (Güzelçoban, 2007)

In most flat roofs constituted by traditional systems, rigid thermal insulation layer is generally placed below, close to roof structure. Water insulation places above thermal insulation. This situation causes condensation on thermal insulation layer, because of the arrangement of vapor retarder. As a situation like this, vapor retarder takes place on thermal insulation's cold-side. So, this is not a good solution. Applying vapor retarders or barriers close to thermal insulation's warm-side, arranging air wells above on roof section and using a filter layer (membranes which have holes and will permit water vapor to move both ways) above thermal insulation are required for preventing condensation in roof sections (Figure 10).

Another roof application is called inverted roof. Rijid thermal insulation places above roof section in this application. Water insulation membrane, which will be functioned as vapor barrier at the same

time, is arranged on warm-side of the insulation (Figure 11). Using water resistant thermal insulation materials in this type of applications provides the continuity of insulation material's activity.

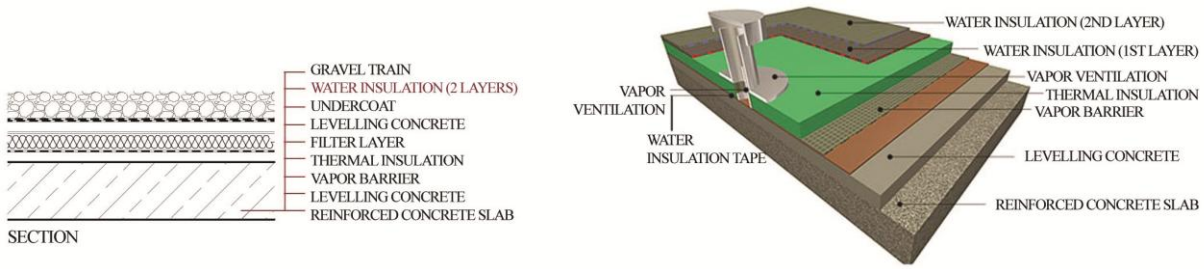

Figure 10: Ventilation and water vapor control in traditional flat roofs (Güzelçoban, 2007)

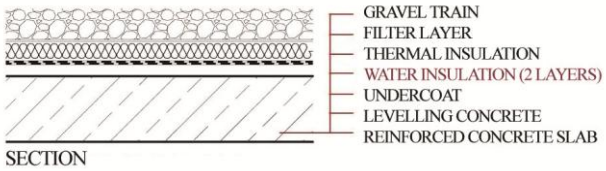

Figure 11: Water vapor control in inverted roofs (Güzelçoban,2007)

On the other hand, vinyl wall coverings may be used as vapor barriers in buildings. These materials, which are used on inner surfaces of building walls, prevent condensation in wall sections by restraining the transition of water vapor between indoor and outdoor environments. Using this type of materials has positive effects in cold climates, but, applying them with a faulty detail solution may cause various problems such as bad mould growth and damages on walls etc. So, using safety detail solutions and materials in right places is very important for controlling water vapor.

Besides, buildings are generally artificially cooled in some very humid tropical and subtropical climates. For this reason, outer surface of thermal insulation is the warm- side. So, using vapor barrier on outer side of the insulation would be better. However, using vapor barrier could not be required in some mild climates.

2.3 Providing Vapor Ventilation

Another principle to take into consideration for controlling water vapor in buildings is arranging ventilation for permitting vapor exit from places or sections where water vapor are. Exit of water vapor from cold-side of any vapor barrier should be provided easily on these type of solutions. For this purpose, maybe air wells should be arranged in sections. At the same time, it is important not to use vapor impermeable materials on the cold-side of thermal insulation in this point of the section. Thus, water vapor passed from vapor barrier, should be prevented from trapping in the section. .

However asphalt-saturated felt and polypropilen fabric air barrier sheets are effective materials to passage of air and water. At the same time, these materials are permeable to the passage of water vapor. These specifications make them appropriate especially for using on the cold-side of wall sections. On the other hand, polyethilen sheeting and metal foils are impermeable to water vapor and should never be used on outside of a wall in cold climates.

Providing vapor ventilation is important in roofs as walls in buildings. Bad mould may be grown in a non-ventilated roof (Figure 12). Preventing this problem, also ice dams on roofs and summertime overheating of a building may be provided by ventilation. Also, removing water vapor from the section of a roof is possible by ventilation. Roof sections or gatters ventilation may be produced by various openings in roofs, eaves, ridges or gable walls (in cold roofs) (Figure 13).

Figure 12: Bad mold growth on insulation materials in a cold roof (Güzelçoban, 2007)

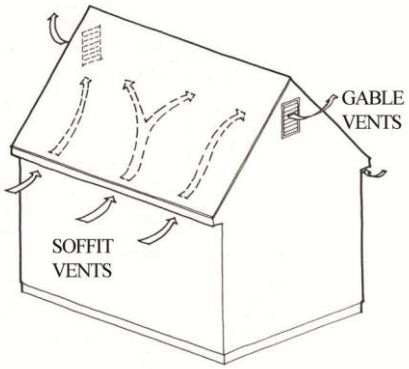

Figure 13: Ventilation of gatters (cold roof) for controlling water vapor (Allen, 1992)

Ventilation in which thermal insulated roof applications applied with ceiling surface directly (warm-roof) is provided with air wells in roof section. Air wells may be arranged between pressure bars or is provided by different dimensioned wooden timbers used in roof section (Figure 14; Figure 15).

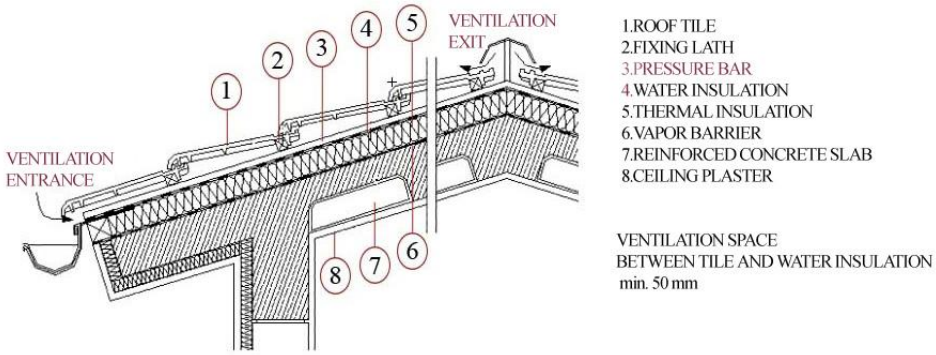

Figure 14: Ventilation solutions for controlling water vapor in roofs (Warm roofs) (Güzelçoban, 2007)

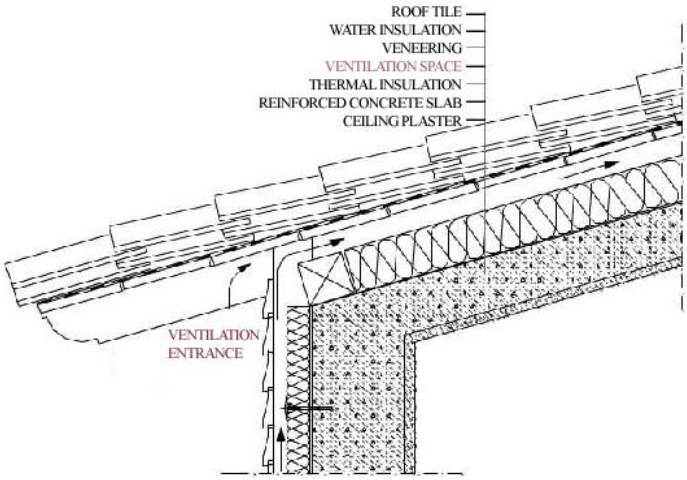

Figure 15: Ventilation solutions for controlling water vapor in roofs (Warm roofs) (Güzelçoban, 2007)

2.4 Providing Condensation Drainage

Arranging channels and weep holes where condensation may occur in a building for removing condensated vapor without damaging is another principle of controlling vapor. Wet rots may be seen on building materials or elements, if there is no drainage hole for taking condensated vapor away (Figure 16).

Drainage details may be seen in slope glazing or skylight systems and some other door or window systems (Figure 17). Details are arranged in to collect or drainage the condensated vapor on glass surfaces in cold airs. Condensate gutters may be designed below aluminium structures of glazing systems.

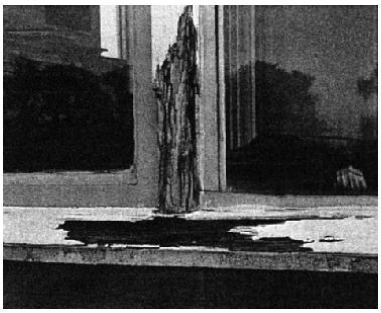

Figure 16. Wet rot and detach on wooden window (Ransom, 2005)

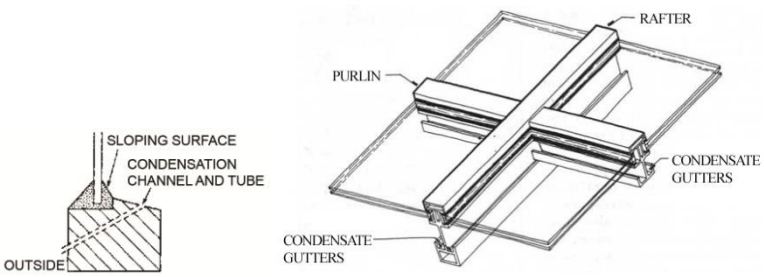

Figure 17. Condensated vapor control in different window systems (Ransom, 2005; Allen, 1992)

3 CONCLUSION

As a result of different temperatured environments and cold surfaces, water vapor condensates. Because of this condensated vapor, various failures may be seen in buildings or building components. Also, building users health, natural or artificial environment or economies of countries may be effected in negative ways.

In order to remove the negativities of water vapor from buildings, the required precautions should be taken in such parts as building envelope or components, which have possibilities to face with condensation. These precautions should be determined with detail solutions in building design process and applied in site with true lobour in application process. Main required principle for controlling water vapor in detail design process is to prevent condensation. Balancing temperatures between indoor and outdoor environments should be required.

In conclusion, it is possible to control water vapor or prevent building failures by using architectural detail solutions or building materials. So, there are some principles to take in account in detail design as follows:

- Providing warm interior surfaces
- Using vapor retarders on warm-sides
- Providing vapor ventilation
- Providing condensation drainage (Allen, 1992).

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