materials of the walls in the new treatment technique for rising damp: ventilation of the wall bases.

Key words: Ventilation of the Wall Base, Treatment of Rising Damp, Old Buildings.

Introduction

Any action taken on built heritage today requires a thorough, objective understanding of the exact situation involved.

The multifaceted activity of carrying out interventions on architectural heritage is tending to embrace a growing number of crafts, and there is a clearly growing need for a deeper knowledge of the causes of the many problems that affect old buildings, and of the possible treatment solutions.

The domineering need to adopt the best methods and solutions requires extra investment in the preliminary study phases, before the intervention, and in the meticulous choice of the best technical solutions to be used in each situation.

In the past, one parameter that had to be borne in mind when choosing where to site major buildings was proximity to water lines, to ensure easy supply. This has meant that today damp is one of the leading causes of deterioration in historic buildings, with rising damp being one of the commonest manifestations, but one for which the treatment is most complex.

It is important to refer that a large number of Portuguese monuments and old constructions present nowadays damp problems namely rising damp problems which brings not only the appearance of algae and mould (due to the high relative humidity of the environment), but it can also cause other pathologies, with even more serious consequences.

The authors believe that many of the techniques currently used to reduce rising damp are ineffective, especially when the walls are fairly thick and their composition is particularly heterogeneous.

Laboratory of Building Physics at the University of Porto has carried out experimental and numerical studies to help ascertain the efficiency of a technique to treat rising damp. The technique consists of ventilating the base of the walls of monuments and old buildings either through a natural ventilation process or by installing a hydro regulated mechanical device.

This new treatment technique has also been used in several churches in northern Portugal.

Wall-Base Ventilation: Experimental and Numerical Validation

Ventilated peripheral channels should be dug outside and/or inside the affected walls when there is lateral infiltration, that is, when the depth of the wall is greater than the maximum depth of the water, since it does not completely prevent capillary suction: it merely reduces it. By making trenches round the affected walls, lateral infiltrations are prevented, on the one hand and, on the other, water evaporation inside the trenches is significantly increased. The depth of the trenches should never be greater than the depth of the foundations, for safety reasons (Figure 1).

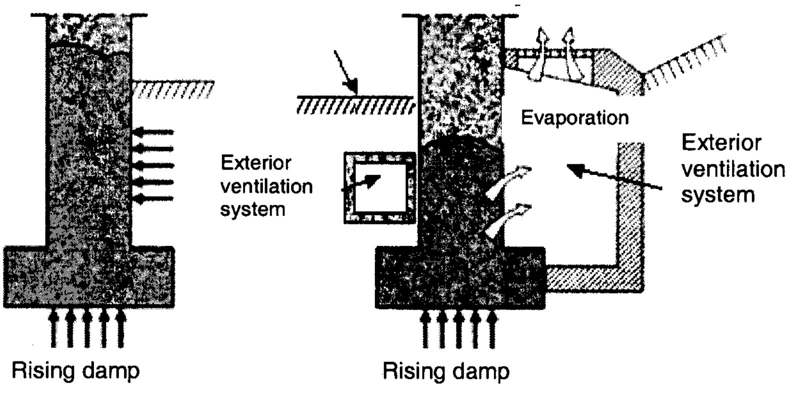


Figure 1 : Peripheral channels

Although this is not a new technology, it has neither been used very much nor studied scientifically in order to validate it/find its scientific dimension.

Experimental Study

Physical Model

The selected physical model consists of a prismatic system measuring 1.58 x 2.00 x 0.20 m3, water-proofed on the two top sides to prevent moisture in this direction, with walls made of limestone slabs measuring 30 x 20 x 200 cm3, with 1 cm thick lime mortar joints (Figure 2).

These experiments were meant to characterize how these walls were affected by rising damp in view of different boundary conditions. Some of the tested configurations are shown in Table 1.

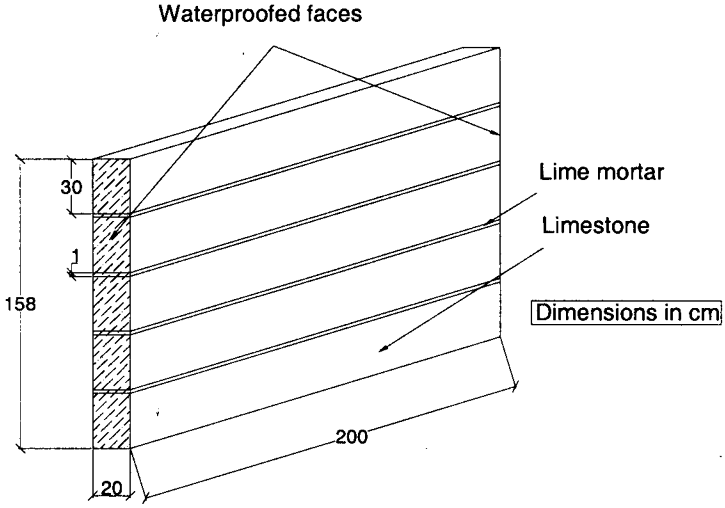
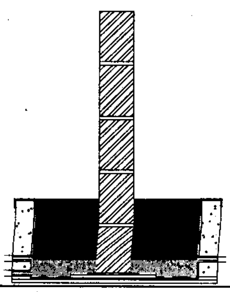
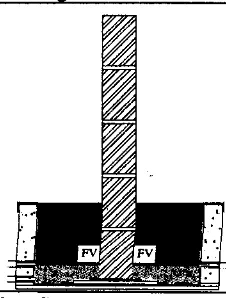


Figure 2 : Physical model

Table 1 : Different boundary conditions

Configuration 1	Configuration 2
	
Configuration 1	Configuration 2
Both gaps is filled with sand	A forced ventilation system is placed at the base of the wall

To evaluate moisture transfer inside the walls, we inserted probes at different heights and different depths to measure relative humidity and temperature. These probes were then connected to a data acquisition and recording system.

Presentation of the Results

In configurations 1 and 2 we measured the behavior of a wall with both sides underground by placing sand on both sides of the wall up to a height of 45 cm above its base.

In configuration 2, since we wanted to assess the effect of placing a ventilation system at the base of the wall, we placed a ventilation box on both sides of the wall. We left two openings to which we attached flexible tubes to ventilate the box. We attached a mechanical ventilator at one opening and left the other one free to allow air to enter freely (Figure 3). This extraction system was left running for the duration of the test so that we could make sure the temperature and relative humidity inside the box were identical to the conditions we had in the laboratory.

Figure 5 illustrate the change in relative humidity in the cross-sections located 61.5 cm (Figure 4) above the wall base.

The following main conclusions were drawn from the experimental research:
Placing a ventilation system at the wall base is a good technique for reducing the level of rising damp.

After the experimental study, some questions remains: is the wall thickness a problem and the material properties have they any influence?

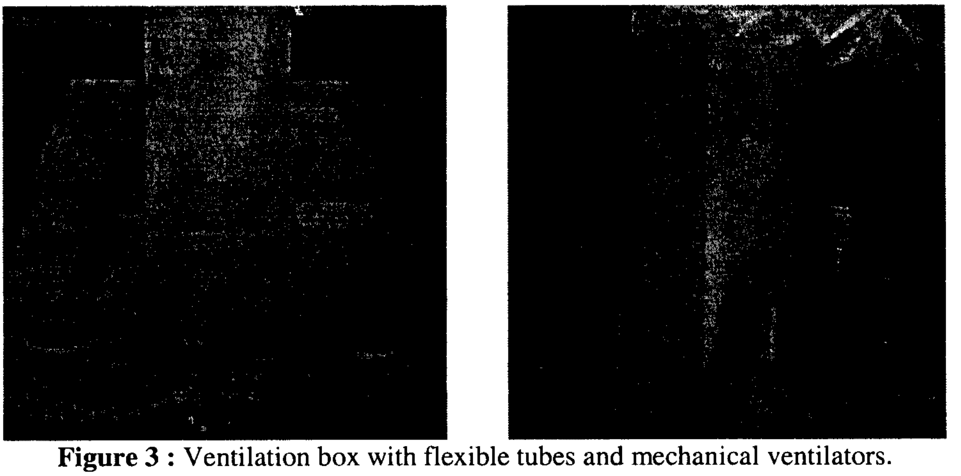


Figure 3 : Ventilation box with flexible tubes and mechanical ventilators.

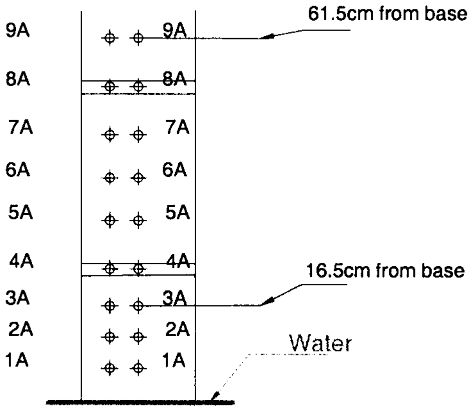


Figure 4 : Position of the probes in the transversal section.

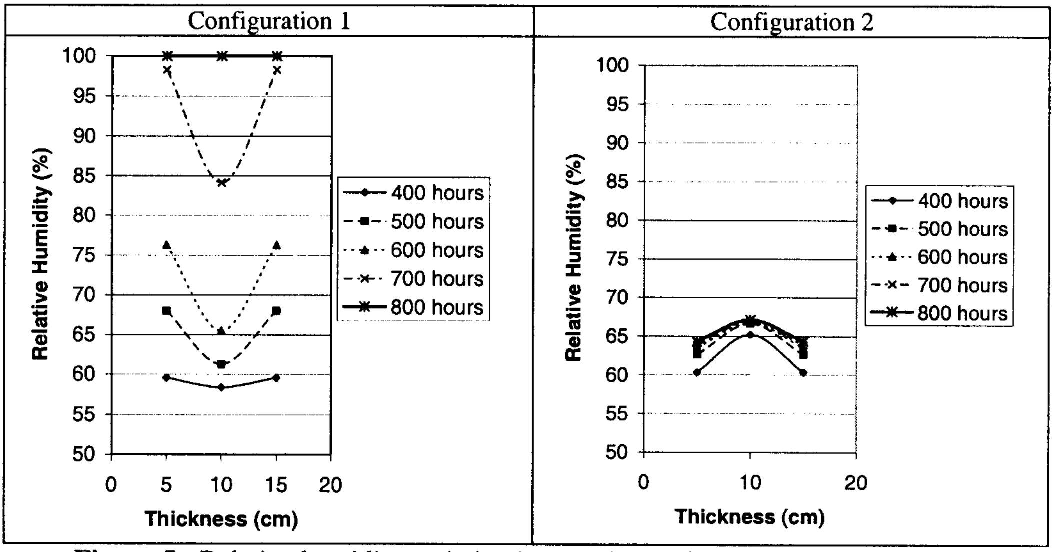


Figure 5 : Relative humidity variation in a section at 61.5 cm from the base.

Numerical Simulations

The automatic calculation programs to evaluate changes in the moisture content and temperature inside walls are essential instruments in simulating the wall's behavior in the presence of humidity, depending on the internal and external climactic conditions. The automatic calculation program used in the numerical simulations was WUFI-2D, developed in the Fraunhofer Institute for Building Physics.

The experimental campaign was limited to considering a single wall, 20 cm thick, but Portugal's ancient building can actually have walls up to 1.00 m thick. A series of numerical simulations was thus performed to find the behavior of walls of different thickness.

Heat and moisture flows across construction materials and elements are found in function of heat and moisture transfer equations, boundary conditions and the physical and hygro-thermal properties of the materials concerned. The influence of some of these properties will be analyzed here. There are various properties that may interfere with the transfer of heat and moisture within construction materials, and, of these, the absorption coefficient of water and the vapor diffusion resistance factor were chosen. The first is the parameter most directly related to the movement of water in liquid phase, and the second is more directly related to the movement of water in the vapor phase.

Two separate situations were simulated:
- A wall buried up to 45 cm of its base;
- A wall buried up to 45 cm of its base, but with its base ventilated such that the conditions of relative humidity and temperature inside the ventilation chamber were identical to those of the respective exterior environment.

The numerical simulations were performed with a wall of natural stone without joints whose properties were:
- Bulk density – 1980kg/m3
- Porosity – 0,23m3/m3
- Water vapor diffusion resistance factor – 20
- Free water saturation – 210kg/m3
- Reference water content – 35,6 kg/m3
- Water absorption coefficient - 0,043 kg/(m2) √s
- Thermal conductivity dry – 1,7W/mk

<u>The Influence of Wall Thickness</u>

Figures 6 and 7 show the water content profiles for the two situations studied, for walls with thickness between 0.20 m and 1.00 m, after 2 years simulation.

As expected, the level reached by the moisture front increased as the thickness increased. It was further found that when the ventilation system was placed at the base of the walls, the moisture front decreased.

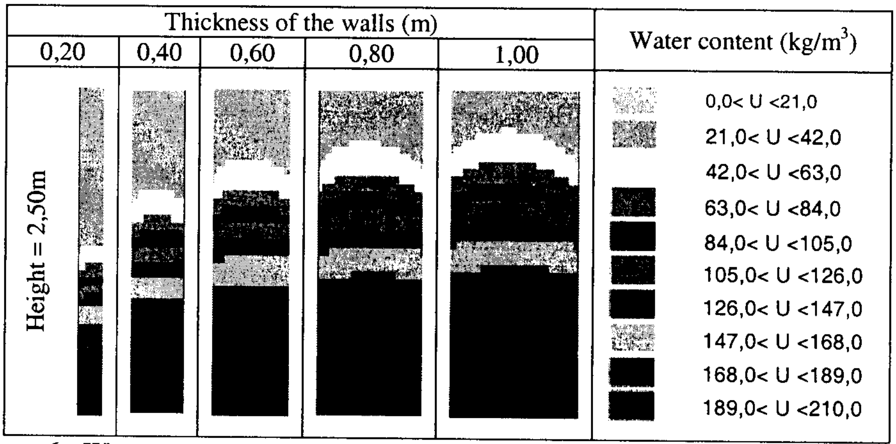


Figure 6 : Water content variation along the transversal section (without ventilation)

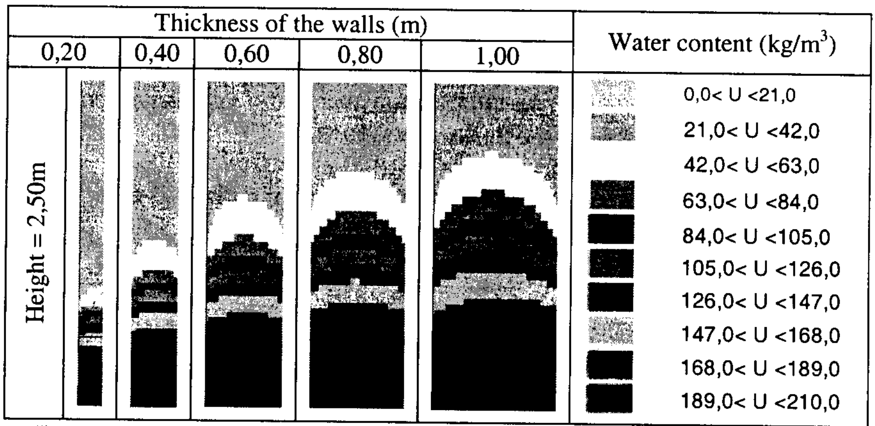


Figure 7 : Water content variation along the transversal section (with ventilation)

The Influence of the Water Absorption Coefficient

Figures 8 and 9 show the water content profiles for the two situations studied, for materials with water absorption coefficient between 0,005 (kg/(m2) √s) and 0,043 (kg/(m2) √s), after 2 years simulation.

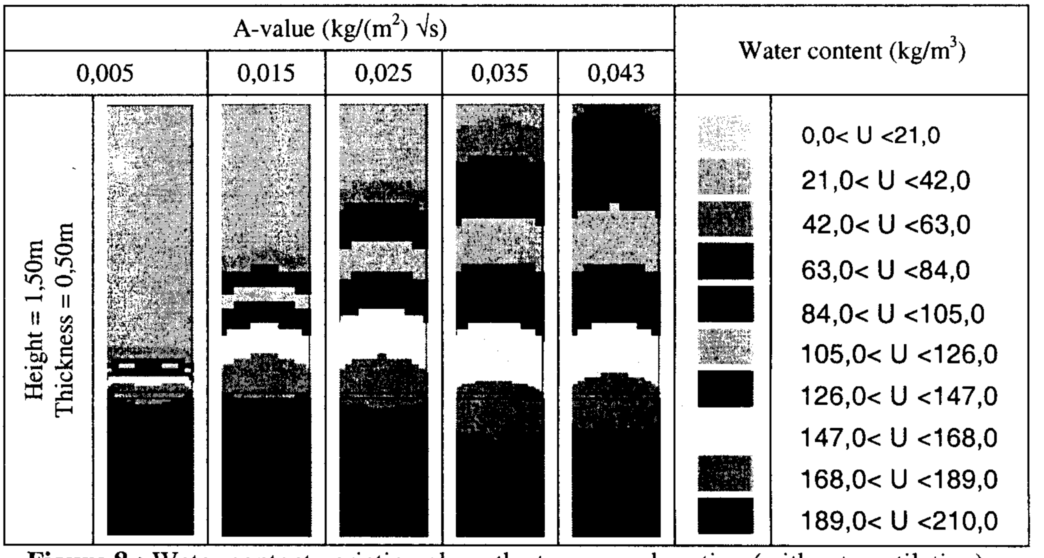


Figure 8 : Water content variation along the transversal section (without ventilation)

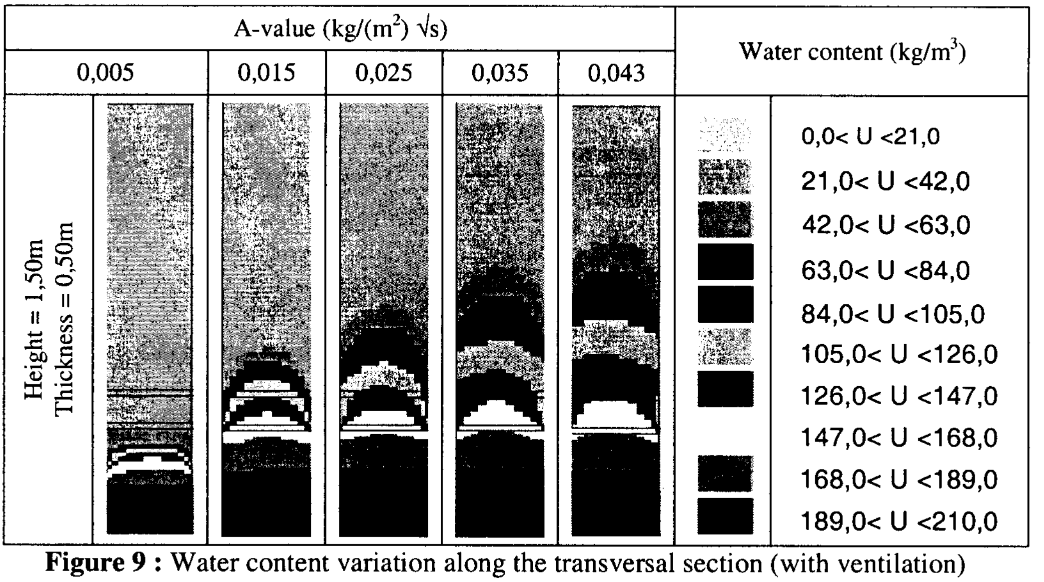


Figure 9 : Water content variation along the transversal section (with ventilation)

As expected, the level reached by the moisture front increased as the water absorption coefficient increased. It was further found that when the ventilation system was placed at the base of the walls, the moisture front decreased.

The Influence of the Diffusion Resistance Factor -μ

Figures 10 and 11 shows the water content profiles for the two situations studied, for materials with diffusion resistance factor dry between 20 and 30 after 2 years simulation.

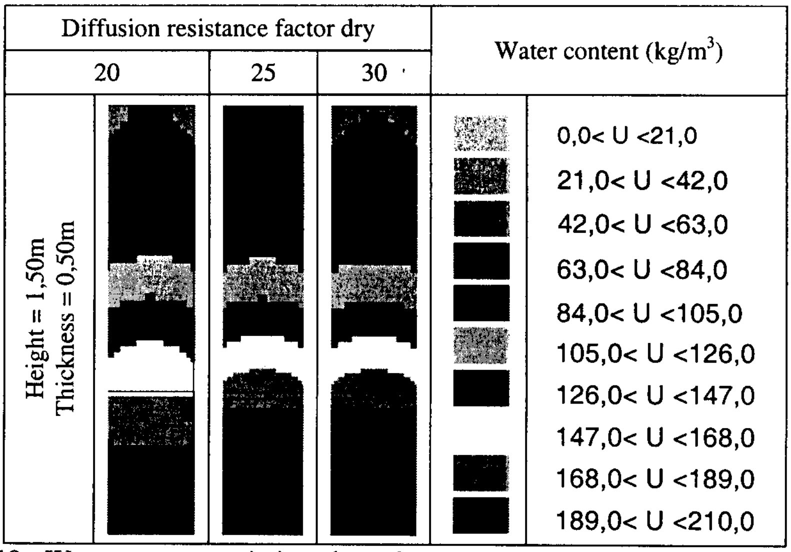


Figure 10 : Water content variation along the transversal section (without ventilation)

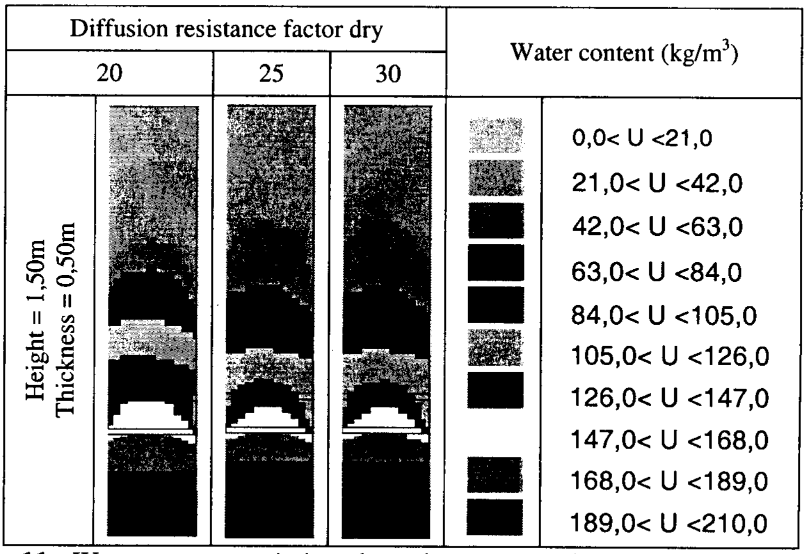


Figure 11 : Water content variation along the transversal section (with ventilation)

As what diffusion resistance factor dry concerns we can conclude that this parameter does not have a strong influence in the level reached by the moisture front. It was further found that when the ventilation system was placed at the base of the walls, the moisture front decreased.

Conclusion

The main conclusions are as follows:

In historic buildings, the traditional techniques for treating rising damp are not effective;

Ventilation of the base of walls is a simple technology that offers great potential;

The varying thickness of the walls (0.20 - 1.00 m) has a slight influence on the efficacy of the wall-base ventilation, but the improvement in the functioning of the wall after the introduction of the ventilation system is clear.

Regarding the influence of the materials' properties, the most important parameter is the absorption coefficient of water, which is as expected, since it is parameter that best characterizes the movement of water in liquid phase, within construction materials.

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