Walls with Rising Damp Problems: Predicting Water Capillary Rise

Ana Sofia Guimarães

João Delgado

Vasco Peixoto de Freitas

Summary

1. INTRODUCTION
2. THEORY
3. NUMERICAL SIMULATION
4. RESULTS AND DISCUSSION
6. CONCLUSIONS

1. Introduction

Rising damp

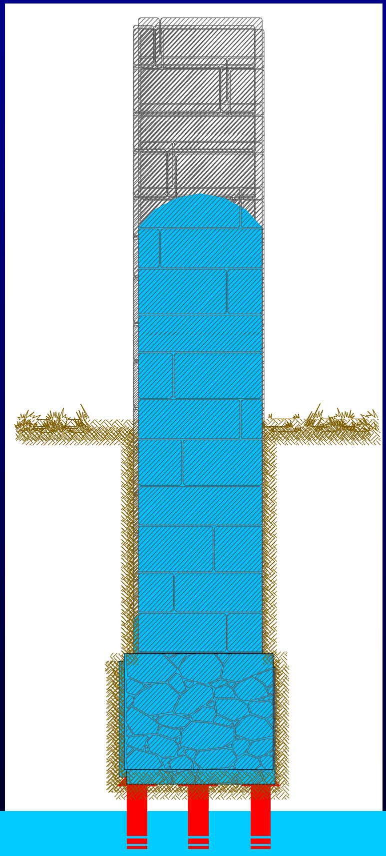
↓

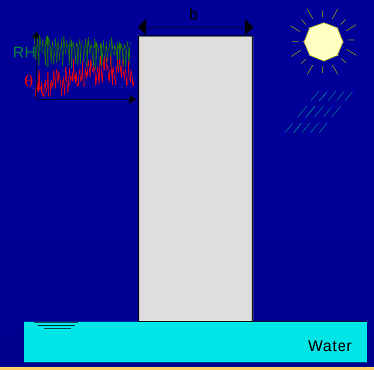
One of the main causes of old buildings degradation

The conservation of historic buildings has become important nowadays and has developed significantly in recent years

↓

The treatment of rising damp in historic buildings walls is very complex, due to the thickness of the walls and the fact that they are built from different materials





1. Introduction

Building Physics Laboratory (LFC) - University of Porto, Faculty of Engineering (FEUP)

important research into the problems of rising damp

This paper presents:

Analytical study of rising damp

(sharp front theory for capillary absorption)

Numerical results, using WUFI 2D

<u>Comparison between analytical predictions and numerical results for steady state height of rise.</u>

2. Theory

Hall and Hoff (2002)

Absorption inflow and evaporation loss in balanced

(Disregarding gravitational forces)

$$b\frac{di}{dt} = b\frac{S}{2}t^{-1/2} - eh$$

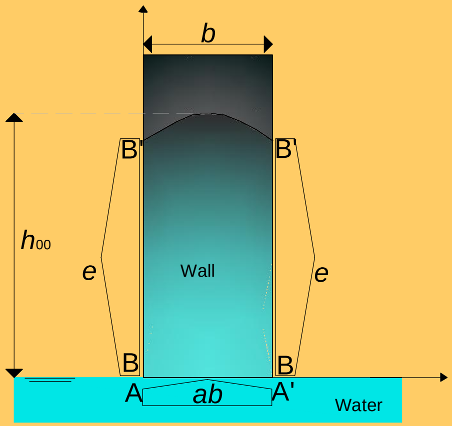
absorption — evaporation

$$i = St^{1/2} = \theta_w h$$

$$\frac{dh}{dt} = \frac{S}{2\theta_w}t^{-1/2} - \frac{eh}{b\theta_w} \Rightarrow \frac{dh}{dt} = \frac{S^2}{2\theta_w^2}\frac{1}{h} - \frac{eh}{b\theta_w}$$

$$h = S\sqrt{\frac{b}{2e\theta_w}\left[1-\exp\left(-\frac{2e}{b\theta_w}t\right)\right]}$$

$$h_\infty = S\sqrt{\frac{b}{2e\theta_w}}$$



b	wall thickness (m)
i	volume of liquid absorbed (m3/m2)
θw	liquid bulk volume (-)
t	time (s)
S	sorptivity coefficient (m/s1/2)
e	evaporation potential (m/s)
h	rising damp height (m)

3. Numerical Simulation

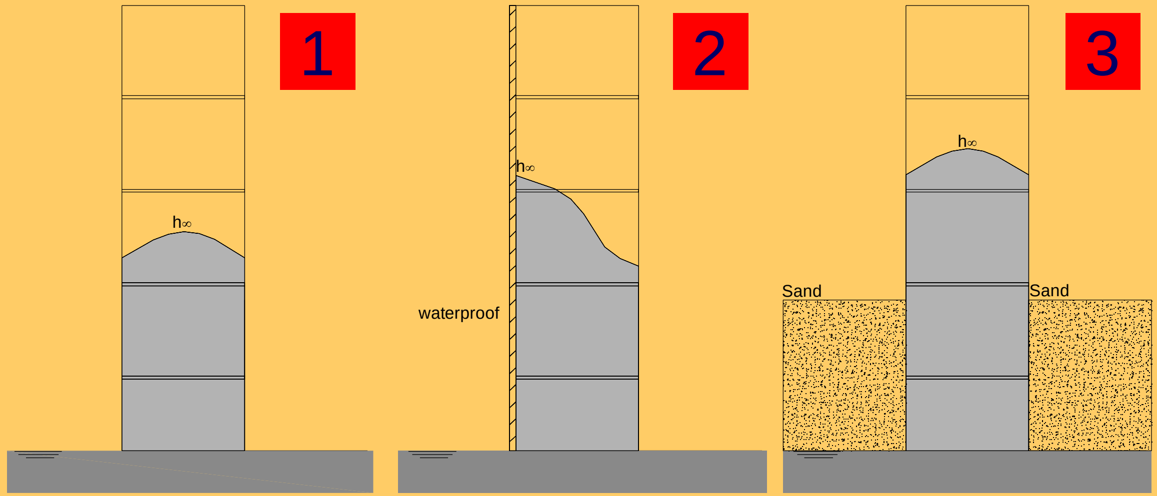
WUFI-2D

Building Physics Laboratory (LFC)

		Limestone		Dolomite	Sandstone
Bulk density, ρ (kg/m^3)		2155		2278	2224
Heat capacity, c_p (J/kgK)		1000		1000	771
Porosity, ε (%)		19.7		20.5	17.0
Thermal conductivity, λ_T *(W/mK)*		1.33		1.50	1.68
Vapour diffusion resistance factor, μ (-)	Dry cup: Wet cup:	41 29		23	73
Moisture storage function, θ_w (kg/m^3)	φ (%)	*Adsor*	*Desad*		
	4.0	0.521	0.951	Generate by Eq. (8)	Generate by Eq. (8)
	11.2	0.593	1.150		
	34.8	0.872	1.239		
	58.6	1.043	1.628		
	76.3	1.237	2.360		
	80.0	1.334	---		
	84.2	1.584	---		
	92.1	2.381	4.144		
Capillary transport coefficient, D_w (m^2/s)	θ_w=1.7 kg/m^3 θ_w=188kg/m^3	6.6×10^{-11} 6.2×10^{-8}		Generate by Eq. (10)	Generate by Eq. (10)
Water absorption coefficient, A (kg/m^{2}s$^{1/2}$)		0.024		0.067	0.0816
Freewater saturation, θ_s (kg/m^3)		188.0		300.7	89.0

3. Numerical Simulation

WUFI-2D



Configuration 2 was one side completely covered with tiles.
Configuration 3 had saturated sand to a height of 45 cm.
The sand was saturated (100% RH) during the tests.

Aims:
Analyse the influence of waterproof materials
Analyse the influence of the saturated ground

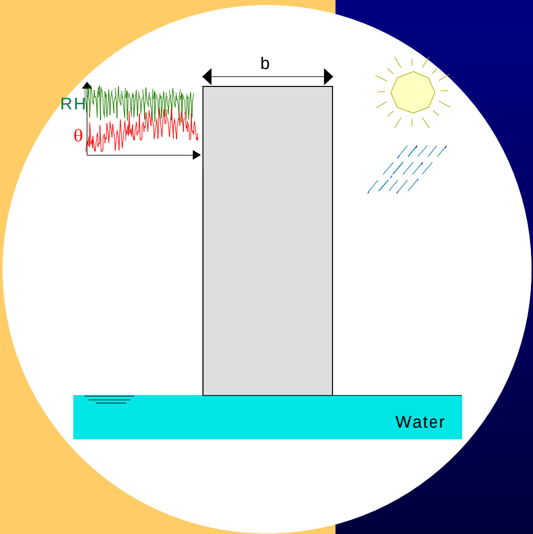
3. Numerical Simulation

WUFI-2D

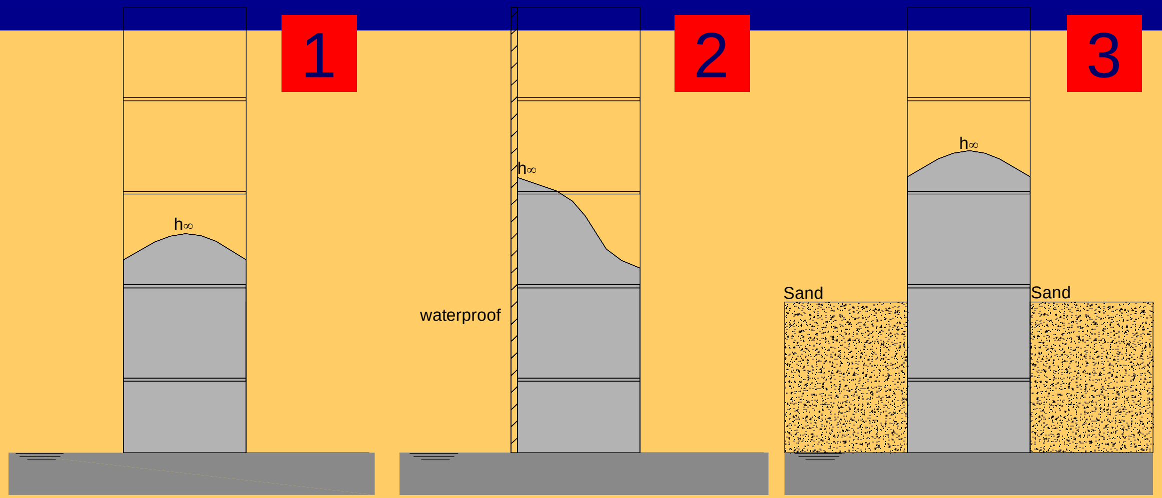
Climate data: Cities of Porto and Lisbon (Portugal) => (METEOTEST 2008)

This program calculates the hourly values for all parameters using a stochastic model and the resulting weather data files are produced in a variety of formats.

The weather data used as input for the model was:
- Temperature (º C),
- Relative humidity (-),
- Precipitation (mm/h),
- Global solar radiation on a horizontal surface (W/m²),
- Short wave radiation absorptivity,
- Long-wave radiation emissivity.



4. Results and Discussion



$$h_\infty = S\sqrt{\frac{b}{2e\theta_w}}$$

$$h_\infty = S\sqrt{\frac{b}{e\theta_w}}$$

$$h_\infty = \frac{h_s}{2} + \sqrt{\frac{bS^2}{2e\theta_w} + \frac{h_s^2}{4}}$$

$S \approx A / \rho_w$

$b = 200mm$

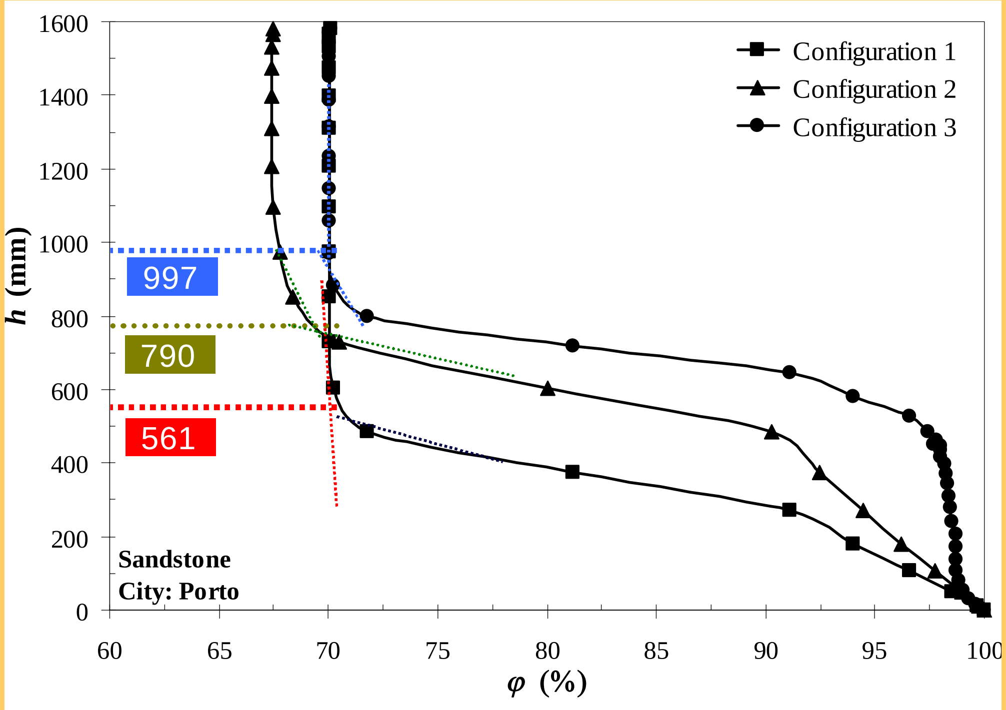
	Limestone	Dolomite	Sandstone
Water absorption coefficient, A ($kg/m^2s^{1/2}$)	0.024	0.067	0.0816

$e = 0.0016mm/\min \Rightarrow Porto, e = 0.0018mm/\min \Rightarrow Lisbon$

$\theta w = 0.177m3/m3$

4. Results and Discussion

Sandstone/ Porto	
Conf. 1	561
Conf. 2	790
Conf. 3	997



4. Results and Discussion

Porto									
h_∞ (mm)	Configuration 1			Configuration 2			Configuration 3		
	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone
Model	107	237	530	152	335	749	557	687	980
WUFI 2D	141	191	561	143	374	790	552	652	997
Lisbon									
h_∞ (mm)	Configuration 1			Configuration 2			Configuration 3		
	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone
Model	104	230	514	147	325	727	554	680	964
WUFI 2D	100	228	542	163	324	720	523	653	993

4. Results and Discussion

Porto									
	Configuration 1			Configuration 2			Configuration 3		
Δh_{∞} (mm)	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone
	34	46	31	9	39	41	5	35	17

Lisbon									
	Configuration 1			Configuration 2			Configuration 3		
Δh_{∞} (mm)	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone	Limestone	Dolomite	Sandstone
	4	2	28	16	1	7	31	27	29

$\Delta h_{\infty} < 5$cm

6. Conclusions

- Rising damp is one of the main causes of degradation of historical buildings
- The mechanisms of moisture transfer are complex, particularly in terms of rising damp in historic buildings
- It became important to study the factors related to this phenomenon

6. Conclusions

- The simple analytical model for rising damp predicts values for the steady height of rise that are consistent with the numerical results

- This study provide a qualitative validation of the analytical model

6. Conclusions

- Regarding the influence of material properties, the most important parameter is the absorption coefficient of water, which was as expected, since this parameter best characterises the movement of water in liquid phase within construction materials

Thank you for your attention

Walls with Rising Damp Problems: Predicting Water Capillary Rise

Ana Sofia Guimarães

João Delgado

Vasco Peixoto de Freitas