ASEC 2024 Conference

The 5th International Electronic Conference on Applied Sciences

04–06 December 2024 | Online

MDPI

Hygrothermal Studies Of Different Arrangements Of A Brick And Adobe Wall On Comsol Multyphisics.

S. Oubeddou[1]*, S. Mounir[1,2], M. Amazal[1], A. Souidi[1], M. Atigui[1], H. Demrati[1]

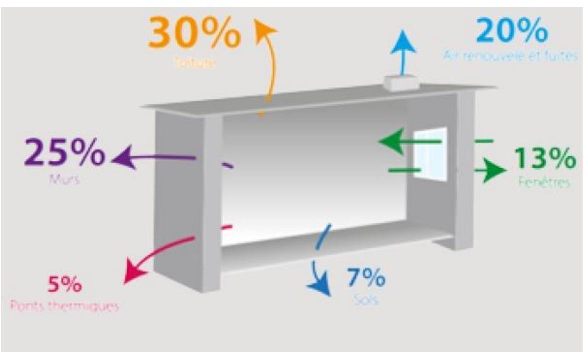
1Thermodynamics and Energetics Laboratory, Faculty of Science, Ibn Zohr University, BP8106, Agadir, 80006, Morocco. (University of_Ibn Zohr).

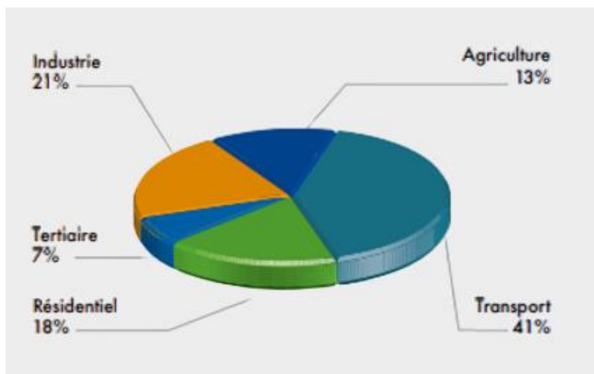
2 National school of architecture Agadir, new complex Ibn Zohr Agadir, 80 000 morocco, (National School of architecture Agadir).

INTRODUCTION & AIM

The energy consumption of the building sector is as high as 25%, broken down into 7% for tertiary buildings and 18% for residential buildings. The building sector is therefore considered to be one of the most energy-intensive sectors in Morocco.
30% of heat escapes from a poorly insulated house through the roof, and 25% through the walls, so the roof and walls are the priority in terms of insulation.

The choice of wall materials helps to reduce energy consumption in buildings.





Sources (AMEE : Moroccan Agency for Energy Efficiency.)

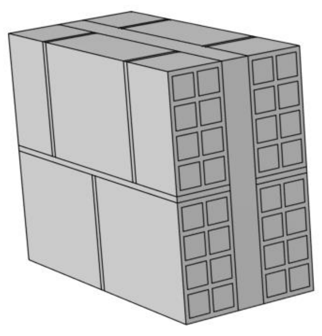
METHOD

The aim of this study is to study the modelling and simulation of coupled heat and moisture transfer in a wall constructed using ecological materials, using COMSOL-Multiphysics, a software package based on the finite element method.

Construction materials and elements studied

- Raw earth from quarryraw earth
- brick
- insulation

Geometric characteristics of the wall studied

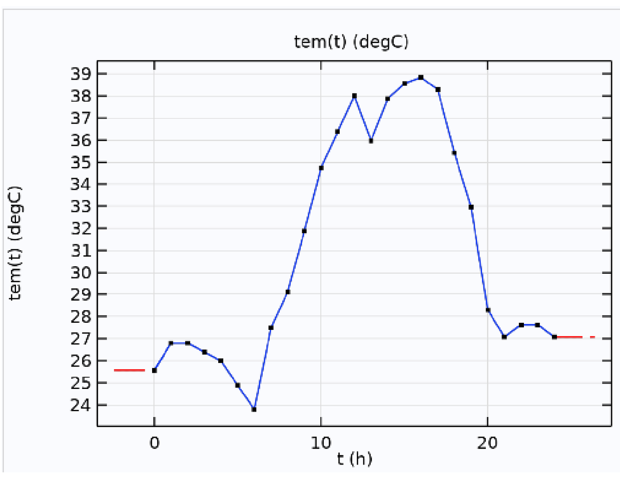


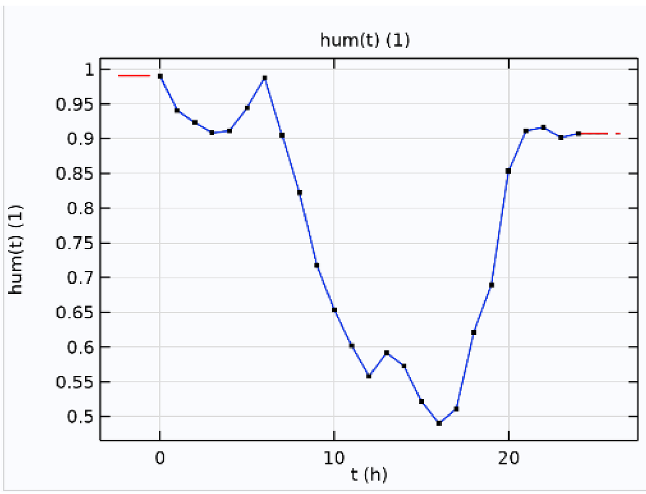
3D view of wall simulated using COMSOL software

Methodology

- Raw materials data
- Model selection and validation
- Mesh size and calculation accuracy
- Launch of the study

Weather conditions





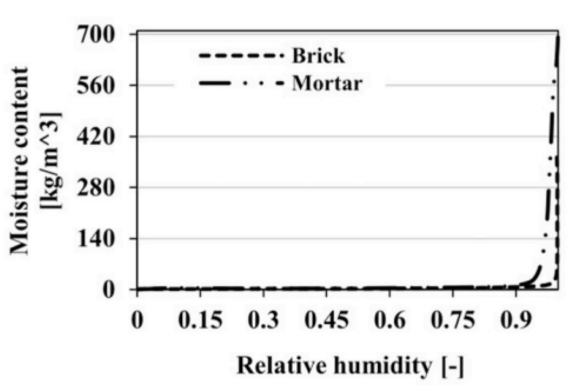
Input data

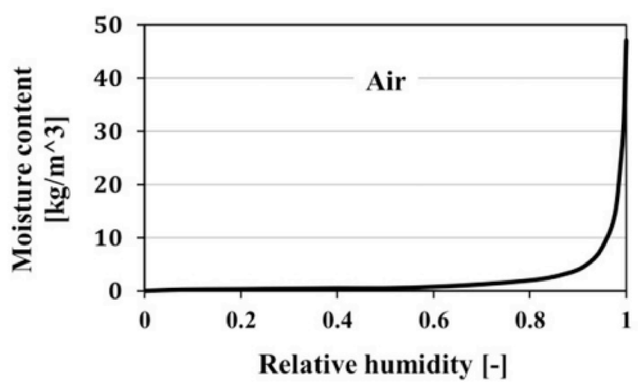
Description	Valeur
Unité de temps	h
Instants de sortie	{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24}

Simulation duration is 1 days, 24 hours

Thermophysical and hydric properties of the materials used :

properties	Air	Red brick	Mortar	Adobe
ρ (kg/m³)	1.23	1600	230	2070
Cp (J/kg.K)	1006.43	840	920	950
λ (W/m.K)	0.026	0.6822	0.6	0.47
δ*10^{-10} (kg/m s Pa)	5.62	0.26	0.0385	0.13





Moisture transfer

- **The conservation of mass equation :**

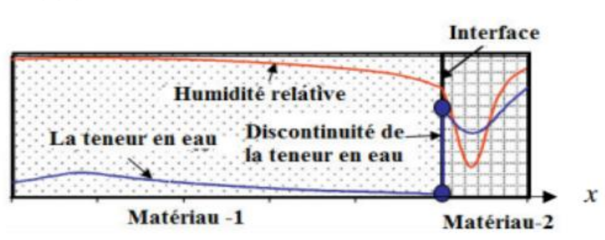
$$\frac{\partial \omega}{\partial \varphi}\frac{\partial \varphi}{\partial t} = \zeta \frac{\partial \varphi}{\partial t} = \nabla.[(D_\omega \zeta \nabla\varphi + \delta_p \nabla (\varphi P_{v,sat})]$$

Heat transfer

- **The energy conservation equation :**

$$\rho_s \left(c_s + \frac{1}{\rho_s} c_e \omega\right) \frac{\partial T}{\partial t} = \nabla. [(\lambda \nabla T + L_v \delta_p \nabla (\varphi P_{v,sat})]$$

Choice of model - Künzel model

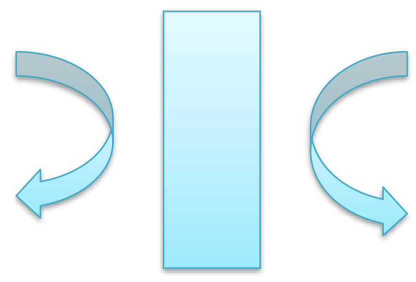


Profile of relative humidity and water content at the interface of two different materials

Boundary conditions

T_{ini}= 25[◦C] , φ_{ini}= 50%

T_{out}(t)
φ_{out} (t)
h_{out} = 15 [W/m² K]
β_{out} = 75 * 10^{-9}[s/m]



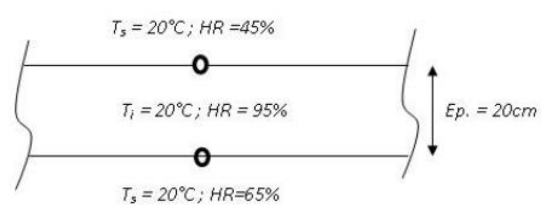
T_{in}= 25 [◦C]
φ_{in}= 50%
h_{in} = 3.25[W/m² K]
β_{in} = 25 * 10^{-9}[s/m]

View of the wall studied with boundary conditions

Numerical validation (HAMSTAD analytical verification case n◦02)

T_{ini}= 20[◦C] , φ_{ini}= 95%

$h_{out,in}$= 25[W/m² K]
$\beta_{out,in}$ = 1 * 10^{-3}[s/m]



Homogeneous wall, HAMSTAD benchmark case n◦02

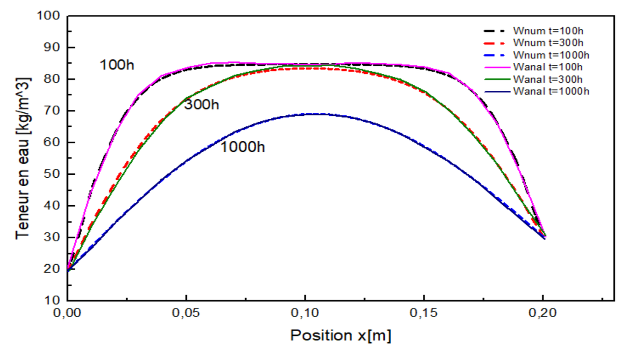
❖ Values of the hygrothermal parameters of the material making up the wall in the test case.

Paramètre	Equation ou valeur	unité
Masse volumique	$\rho_0 = 525$	kg.m^{-3}
Capacité thermique massique	$C = 800$	J.kg^{-1}.K^{-1}
Isotherme de sorption	$w = \frac{116}{\left(1 - \frac{1}{0,118} \cdot \ln(\varphi)\right)^{0,869}}$	kg.m^{-3}
Perméabilité à la vapeur	$\delta_p = 1,0 \cdot 10^{-15}$	S
Coefficient de diffusion	$D_w = 6,0 \cdot 10^{-10}$	m^2.s^{-1}
Conductivité thermique	$\lambda = 0,15$	W.m^{-1}.K^{-1}

RESULTS & DISCUSSION

Digital validation.

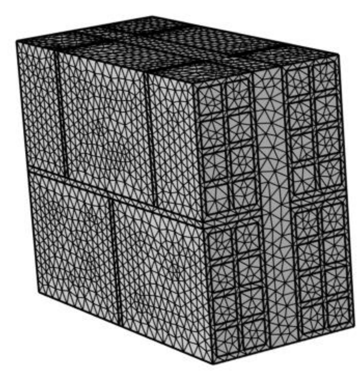
Redistribution of water content in a homogeneous wall at 100h, 300h and 1000h



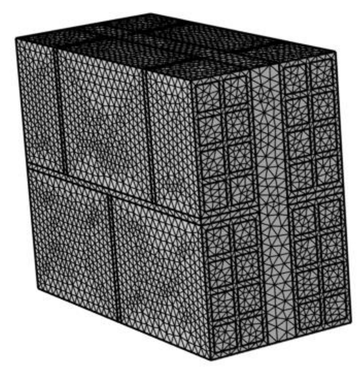
The results of the numerical simulation given by the Künzel model are in perfect agreement with those of the analytical solution provided by hamstad,

Mesh testing

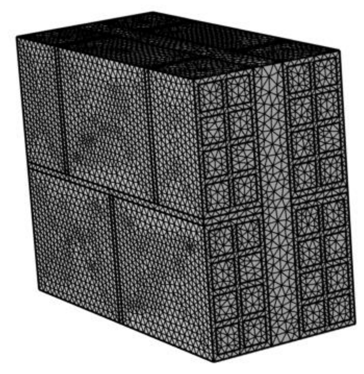
(a)-NEV 107058



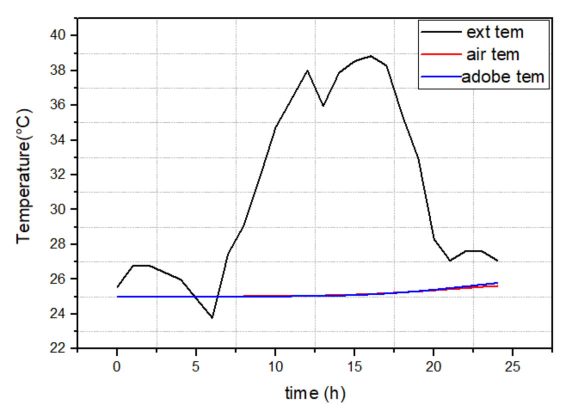
(b)-NEV 163812

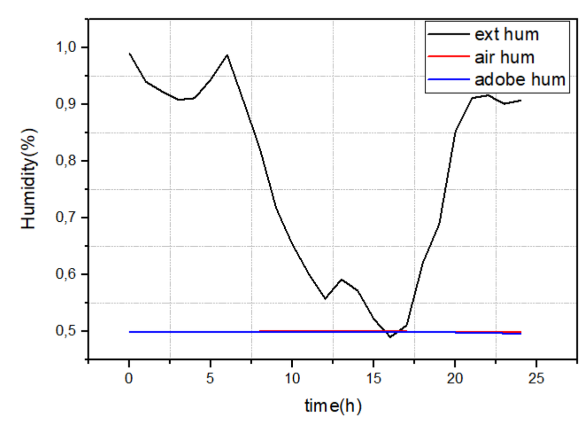


(C)- NEV 264119

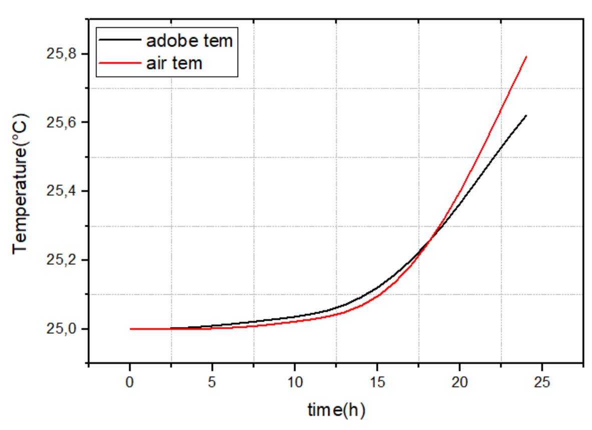


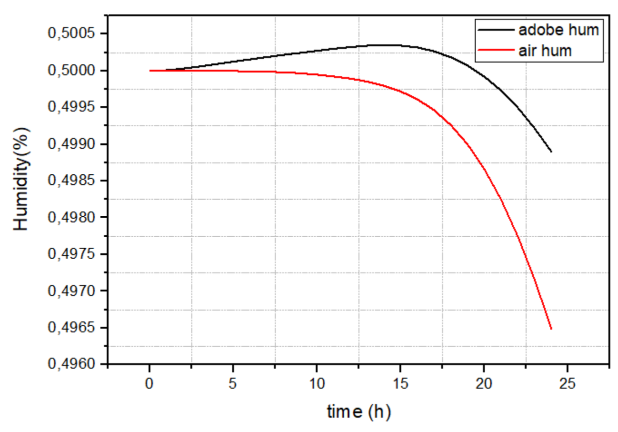
Tetrahedral element for meshing the different configurations used in the simulation (a)-NEV 107058 (b)-NEV 163812(C)- NEV 264119





Time variation of indoor temperature and relative humidity of adobe and air as a function of outdoor conditions (Text,HRext)





Time variation of indoor temperature and relative humidity under both air and adobe configurations

CONCLUSION

- We have tried to highlight the importance of using adobe as insulation in the air space between the double walls, to reduce temperature variations and relative humidity in the interior.
- Hygrothermal comfort can be ensured by using a double partition with adobe insulation to reduce construction costs.

FUTURE WORK / REFERENCES

analysis of the construction envelope must focus on the use of ecological and economical products with local materials, extending the study to acoustic ambiences