Influence of a Refurbishing on an Old Residential Building's Wall in Paris in summer: Mass and Heat Transfer Approach

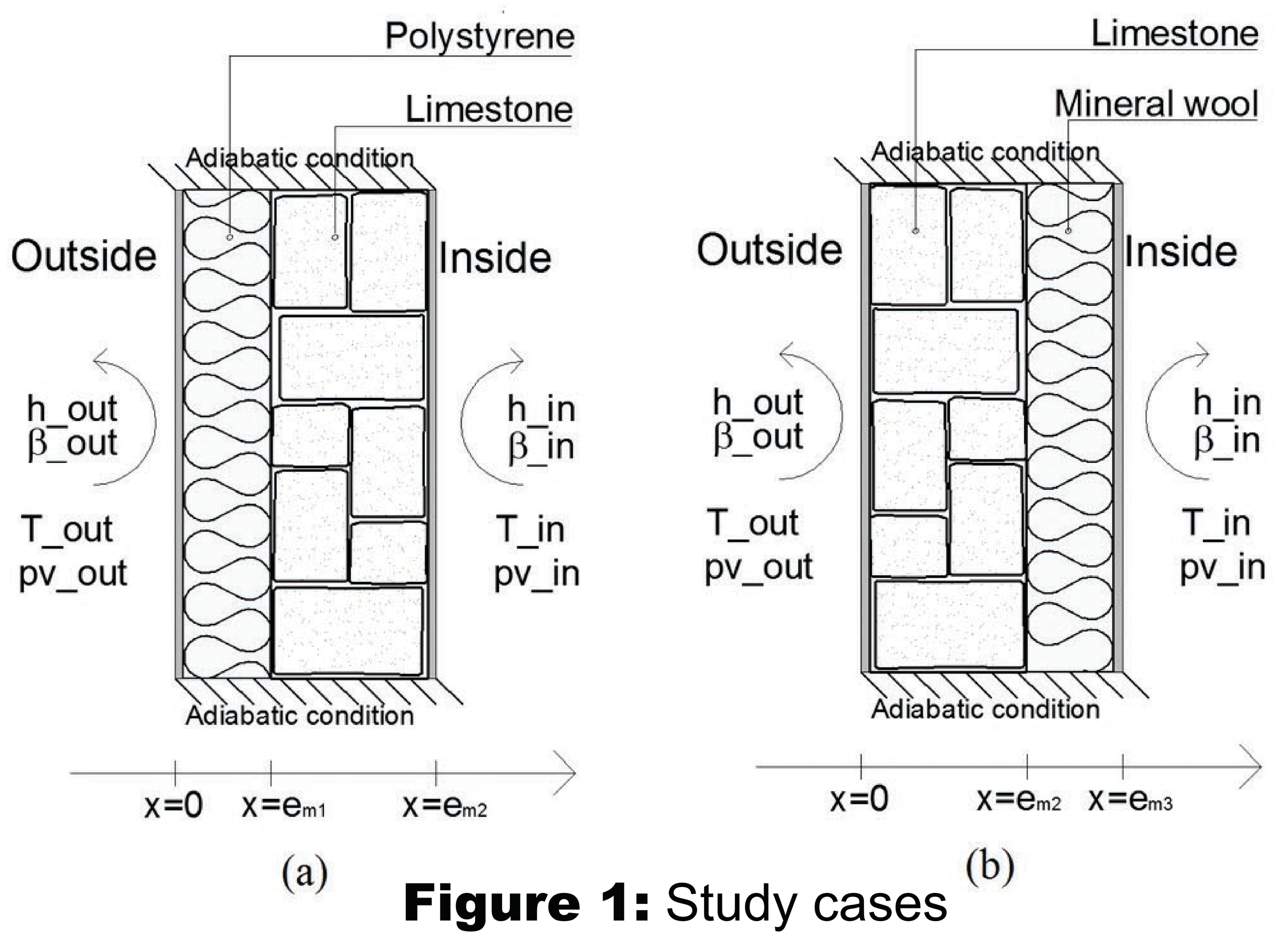
K. Azos-Diaz[1], B. Tremeac[1] ,F. Simon[2], D. Corgier[2], C. Marvillet[1]
1. Laboratoire de Chimie Moléculaire, Génie des Procédés Chimique et Energétique, CNAM, Paris, France;
2. MANASLU Ing., Savoie Technolac, Le Bourget du Lac, France.

Introduction

Old buildings, like in Paris, were built with un-insulated thick walls made of porous materials. French regulation and the Factor 4 approach have result in the implementation of thermal in-sulation that affect the hygrothermal behavior of this kink of buildings. Thus, the evaluation of heat and mass transfer is an important task.

Aim

Evaluate the hygrothermal behavior of two mul-tilayered renovated walls through a 2D PDE model



a) Outside insulation

b) Inside insulation

Figure 1: Study cases

Study case

Two cases are modeled case a) and b) (Figure 1). We assume that two layers are homog-enous with perfect contact between them, which means that contact resistance is ne-glected.

Hygrothermal model

Heat Transfer

$$\rho_s\left(c_{ps}+\frac{1}{\rho_s}wc_{pw}\right)\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(\lambda\frac{\partial T}{\partial x}\right)+h_v\frac{\partial}{\partial x}\left(\delta_p\varphi\frac{\partial p_{sat}}{\partial T}\frac{\partial T}{\partial x}+\delta_p p_{sat}\frac{\partial \varphi}{\partial x}\right)$$

Mass Transfer

$$\xi\frac{\partial \varphi}{\partial t}=\frac{\partial}{\partial x}\left(D_\varphi\frac{\partial \varphi}{\partial x}+\delta_p p_{sat}\frac{\partial \varphi}{\partial x}+\delta_p\varphi\frac{\partial p_{sat}}{\partial T}\frac{\partial T}{\partial x}\right)$$

Using COMSOL Multiphysics

The solutions of heat and masse transfer equations are solved simultaneously in COMSOL 4.4. multiphysics PDE's interface for a 2D model

PDE generic form

$$e_a\frac{\partial^2 u}{\partial t^2}+d_a\frac{\partial u}{\partial t}+\nabla\cdot(-c\nabla u-\alpha u+\gamma)+\beta\cdot\nabla u+au=f$$

PDE's equations for heat and mass transfer are describe and thereby coupled to be modeled. PDE coefficients are replaced by:

$$d_a=\left\{\frac{dH}{dT}=\rho_s\left(c_{ps}+\frac{1}{\rho_s}wc_{pw}\right),\frac{dw}{d\varphi}=\xi\right\}$$

$$c=\left\{\lambda_s+h_v\delta_p\varphi\frac{dp_{sat}}{dT},D_\varphi+\delta_p p_{sat}\right\}$$

$$\gamma=\left\{h_v\delta_p p_{sat}\frac{\partial \varphi}{\partial x},\delta_p\varphi\frac{\partial p_{sat}}{\partial T}\frac{\partial T}{\partial x}\right\}$$

$$e_a=\alpha=\beta=a=\{0,0\}$$

Dependent Variables Temperature T and Relative humidity φ

$$u=\{T,\varphi\}$$

Results

Figure 2 shows temperature and relative humid-ity evolution through materials. We observe that limestone damps down the daily temperature variation. This is explained by the fact that lime-stone has a high heat capacity. Thus, an impor-tant a heat flow is required to cool down or heat up the material by one degree. In mass transfer the modelling duration seems to be too short to assess moisture effect at the interfaces of two materials

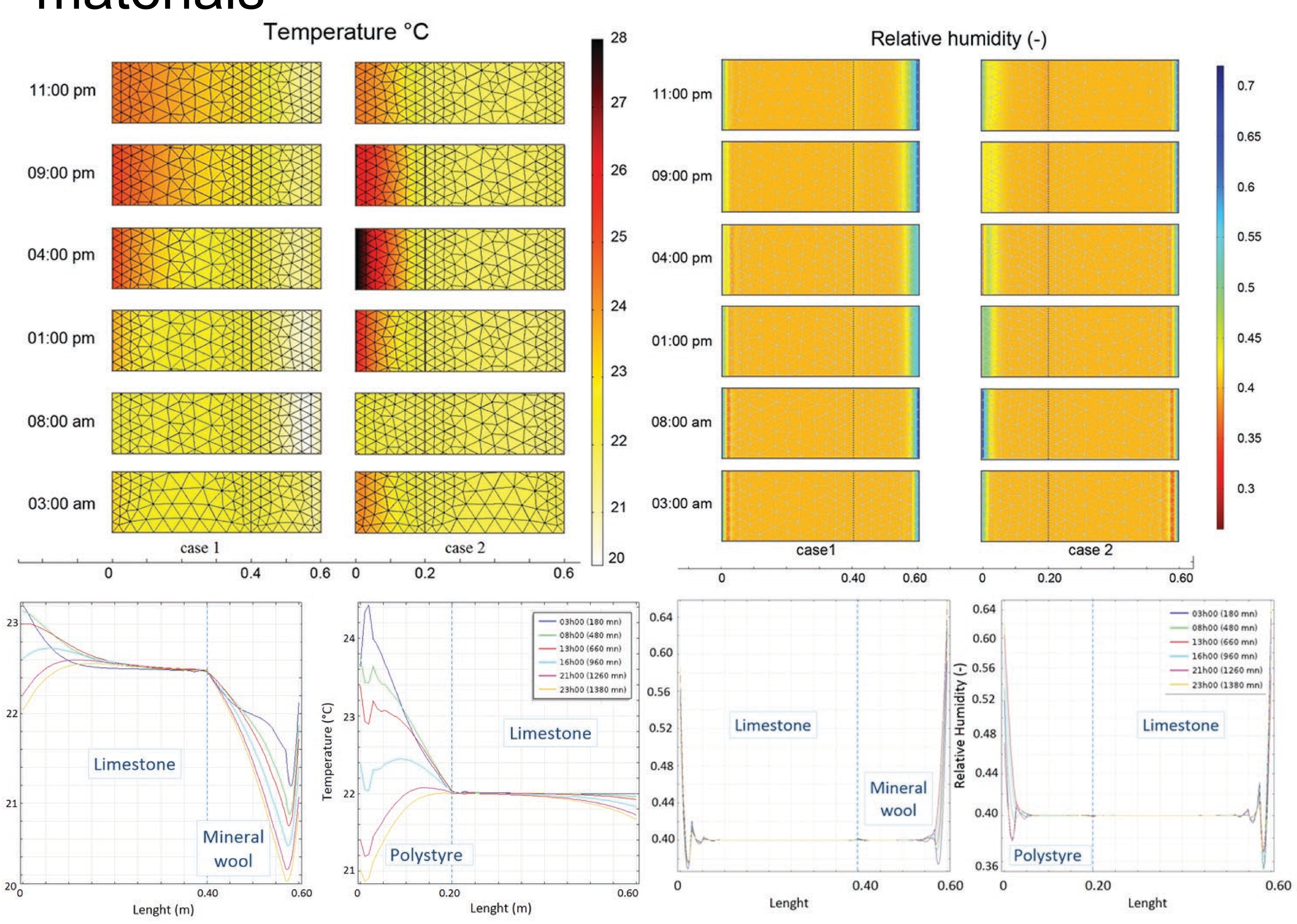


Figure 2: Temperature and relative humidity evolution

Conclusions

In PDE interface mathematical model (simplified model) can be easily integrated by predefined coefficients that allow coupling between govern-ing equations.

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