Experimental data from an In-Situ measurement

Estimation of the R and C of a three-layer wall
Prediction of heat flow density through a three-layer wall tested under real weather conditions

Brief description

Data are obtained from a well controlled experimental set up, designed for the purpose of training dynamic analysis techniques. The experimental wall is created through adding extra insulation to an existing normal external wall of a laboratory. The Gas Concrete is a part of the normal construction of the laboratory, while the two insulation layers have been added to create the test wall. The testing area is 2 meter wide and 1.2 meter high, while the concrete wall is 5 meter wide 2.5 meter high. The wall is facing south-west.
The test wall is a symmetric three layer wall with Gas Concrete insulated on both sides with a glass fibre board layer, see Figure 1. The wall is 204 mm thick. The temperature sensors are positioned at the external side of the glass fibre boards. The Heat Flux meters are mounted in a 3mm wood fibre board which thickness and thermal conductivity were nearly equal to the Heat Flux meter. Data was measured every 5 minutes and the mean value was stored every 30 minutes.

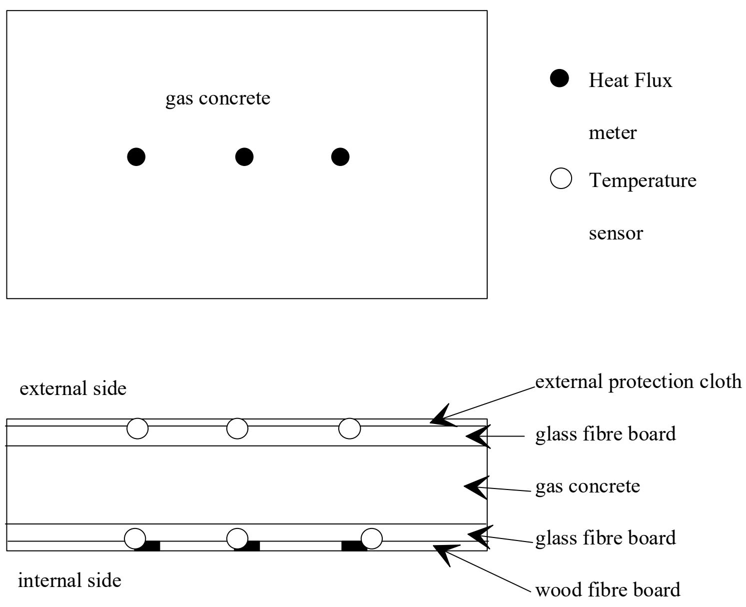

Figure 1. Position of Heat Flux meters and temperature sensors

Given: One data set (called *Data_Cserie1* and *provided as TXT file*) containing 30 minutes mean values (from 5 minute interval observations), are prepared for this three-layer wall exercise. Participants are advised to plot the data and examine it before starting the analysis.

Data_Cserie1 (the estimation data set) consists of mean values of three variables (two Temperatures in ºC and one Heat Flow in W/m^2). During the measurement period the wall was exposed to solar radiation.

Data file starts:	Text	Tint	HF
	11.72967	22.379	1.924219

The heat flow density is assumed to be the average of three heat flow sensors. The external and internal temperatures are assumed to be averages of three temperature sensors each. The external temperature sensors were not directly exposed to the sun but shielded with a special cloth. Each data set contains data for about 31 days and contains each 1500 (5 minute) observations of calculated mean values for every 30 minutes.

Note: concerning the density and moisture in the gas concrete: The density is quite constant and the moisture content is higher at the external side than at the internal side.

Mass transfer in gas concrete is an effect which complicates the analysis from thermal in-situ measurements. Regular measurements have been performed during both periods to obtain information about this phenomenon. When the external temperature is high, vapour diffusion occurs inwards, and the vapour content increases. When the external temperature is low, vapour diffusion occurs outwards, and the vapour content decreases. One might try to assess an effect in the heat flow due to this phenomenon.

The participants are asked to deliver estimates of R and C and estimates of their standard deviation, sR and sC, for *Data_ Cserie1* (thus 4 values, e.g. R, sR, C and sC). They may apply any method that they are acquainted with.

	R	**sR**	**C**	**sC**
Estimated value				

Note:
This exercise has been performed by several people in the past. During the Summer School different approaches and calculation tools will be discussed and made available to the participants, to examine further in detail. Look also for the document: *Hints_for_Homework_SS19.pdf*
Hints:

- **Study the confidence interval of the estimates generated by the applied method**
- **Study the effect of filtering of the data**
- **Analyse the obtained residual from the model output**
- **How well performs the applied model? Cross validation might give additional information**

Definitions.

Although the nomenclature below is common in some approaches and not in others, it will provide an understandable nomenclature.

For this exercise you are asked to estimate parameters and to predict the heat flow. Consider the following variables as illustrated in figure 2.

$q_i(t)$ is the density of the heat flow rate at the internal surface of the wall, positive from the internal to the external side of the wall, at time t, in W/m^2

$q_e(t)$ is the density of the heat flow rate at the external surface of the wall, positive from the internal to the external side of the wall, at time t, in W/m^2

$\theta_i(t)$ is the internal surface temperature at time t, in °C

$\theta_e(t)$ is the external surface temperature at time t, in °C

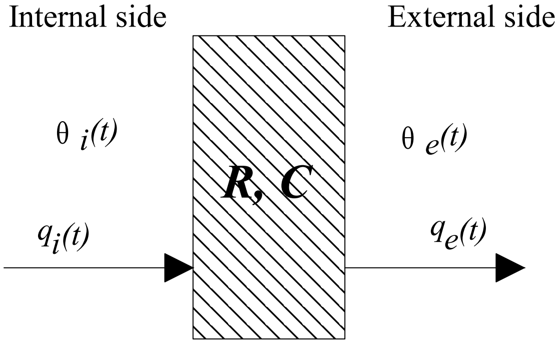

Figure 2. Notation for wall components

Building-physical definitions.

R is the *thermal resistance* (surface-to-surface) defined as the difference between the two surface temperatures in steady state divided by the density of heat flow rate, in °Cm^2/W

C_i is the *internal thermal capacity* per unit area of the wall defined as the amount of heat that goes into the wall per m^2 as the result of a change from one steady state situation to another by increasing the internal surface temperature with 1°C, in $Wh/°Cm^2$

C_e is the *external thermal capacity* per unit area of the wall defined as the amount of heat which goes into the wall per m^2 as the result of a change from one steady state situation to another by increasing the external surface temperature with 1°C, in $Wh/°Cm^2$

C is the *thermal capacity* per unit area of the wall defined as the sum $C_i + C_e$, in $Wh/°Cm^2$