RP1010

MONITORING AND MODELLING THE CSR LOW ENERGY HOUSE

Research Questions

How are the composite walls in the CSR house performing during a day, a month or a year in maintaining comfortable indoor temperature?

Figure 1: CSR house research centre in western Sydney

Methodology

Consider the wall system as part of thermal circuit with a periodic heat flow at outer surface…

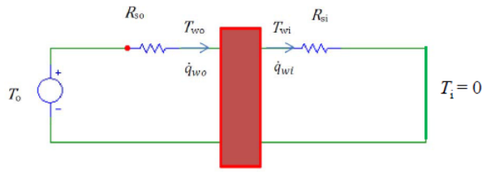

Figure 2: Simplified thermal circuit of the CSR house composite wall system

Assuming the outdoor periodic heat flow is varying in a simple sinusoidal mode, the surface temperature of the external wall $T_{wo} = T_o \cos(\omega t)$

The temperature profile T(x,t) in the wall can be expressed by:

$$T(x,t) = T_o e^{j\omega t}[A\cosh(\gamma x) + B\sinh(\gamma x)]$$

The core equation for solving the temperature of the wall is:

$$k\frac{\partial^2 T}{\partial x^2} = \rho c_p \frac{\partial T}{\partial x}$$

The characteristic – thermal transfer admittance Y_t can therefore be obtained using the following equation:

$$Y_t = \frac{q_{wi}}{T_o}$$

Results

There are four different composite wall types in the CSR house, all these composite walls together formed the external building envelop.

For each composite wall system, the thermal transfer admittance of the composite wall can be calculated and expressed as a function of time.

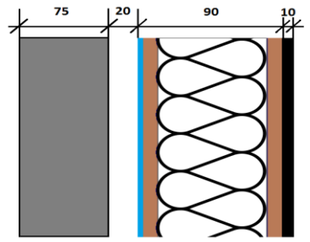

Figure 3: The Hebel™ wall system includes a 75mm Hebel™ concrete layer, a 20mm air gap, 90mm R2.7 glasswool insulation and a 10mm plasterboard.

Based on the thermal circuit model and thermal transfer admittance equation, we can obtain the transfer admittance values which enable us to compare the thermal performance of these wall types with thermal mass effect into consideration.

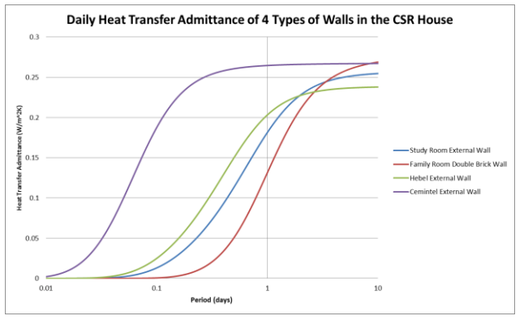

Figure 4: Transfer admittance Y_t as a function of period (days) for four composite wall systems.

The most interesting part of this model is, it reveals the effectiveness of thermal mass when considering 1 day period. As you can see from the above diagram, family room double brick wall, which has the greatest thermal mass, has the lowest heat transfer admittance value (0.13 W/m2K). In the meantime, the lightest composite wall, Cemintel external wall, has the highest heat transfer admittance (0.26 W/m2K). As the simplified heat transfer admittance has the same unit as the U value, higher admittance means the heat flow from external can penetrate the wall and influence the internal temperature much easier.

Conclusion

With this model, we can get the effective U value or R value of any composite wall system as a function of time period. As it consider the effect of both thermal mass and resistance at the same time, the thermal transfer admittance can evaluate the building material's thermal performance in a more holistic way.

Figure 5: CSR house Designbuilder model

Anticipated impacts

This research aims to introduce a parameter to characterise the performance of the building material with a combined consideration of thermal resistance and thermal mass.

With this proposed model, the heat performance of composite wall systems can be easily quantified.

Further information

If you are interested in this project, please visit:

http://lowcarbonlivingcrc.com.au/research/program-1-integrated-building-systems/rp1010-monitoring-and-modelling-csr-low-energy-house

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