Comparison of calculated and measured values of wall assembly tests using Delphin 5

NSB 2011

Anssi Laukkarinen, Juha Vinha
Tampere University of Technology

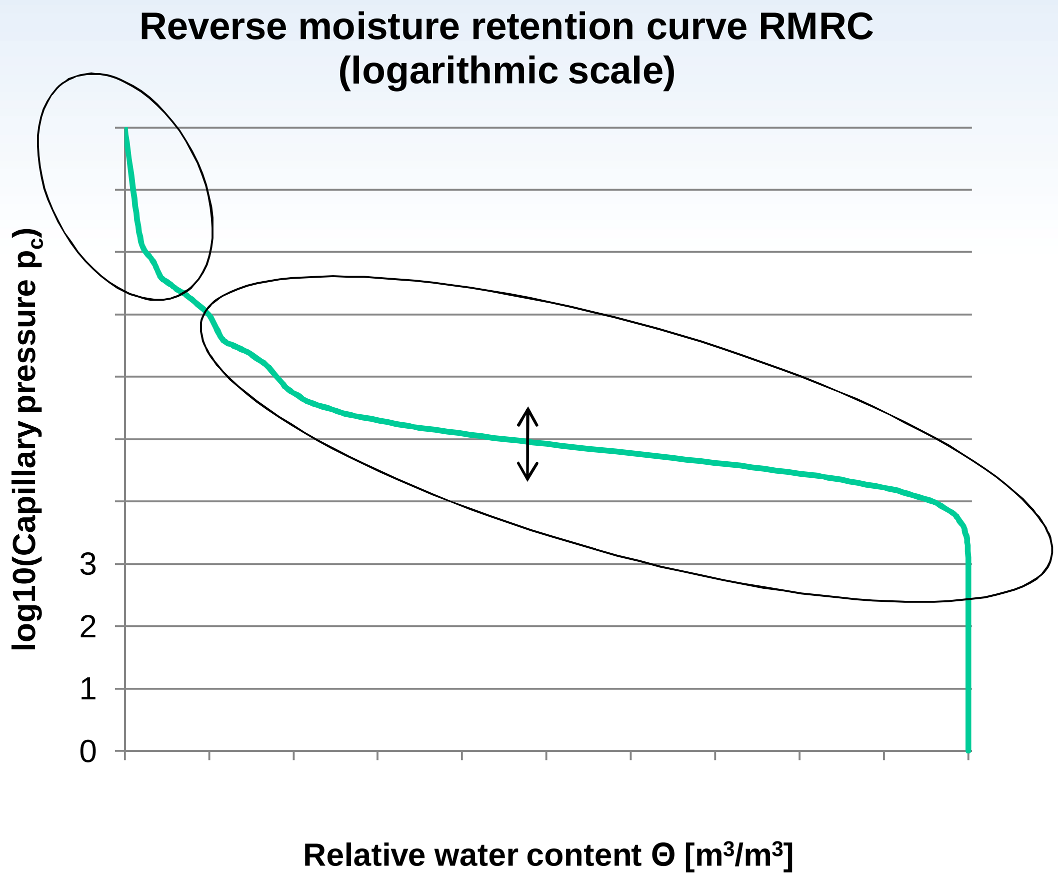
30.5.2011

General

- Definition of material properties
  - Reverse moisture retention curve (RMRC)
  - Liquid water conductivity K_l
- Wall assembly calculations (3 assemblies)
- Conclusions

Reverse moisture retention curve

Hygroscopic range was known from measurements



Values in the capillary range were taken from a suitable library material. The values were matched to continue smoothly.

Liquid water conductivity function $K_l(\Theta)$ 1/3

-The core function

The core relative liquid water conductivity function was calculated from the moisture retention curve

$$K_{l,\,rel} = \frac{\int_0^{\theta_l} p_c(\theta)^{-2}\, d\theta}{\int_0^{\theta_{eff}} p_c(\theta)^{-2}\, d\theta}$$

and

$$K_{l,\,rel} = \frac{K_l}{K_{l,\,eff}}$$

The liquid water conductivity at effective saturation wasn't measured, so it was determined by simulating the water uptake experiment.

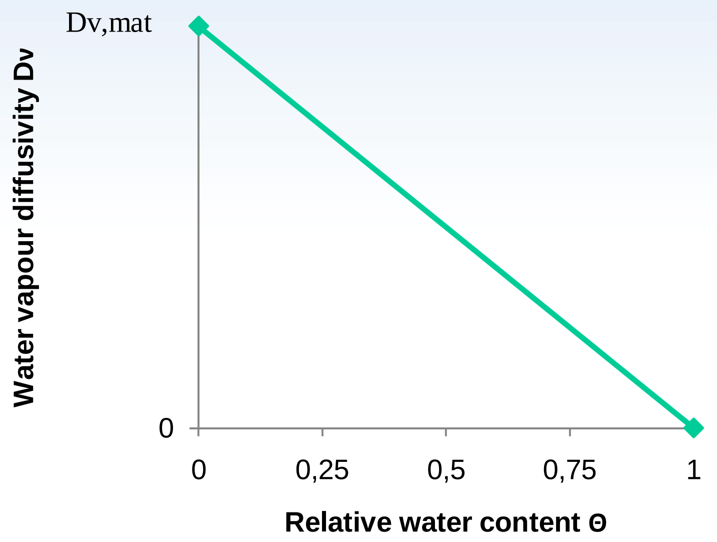
The simulation was repeated with different values of $K_{l,eff}$ until the calculated A_w matched the measured A_w.

Liquid water conductivity function $K_l(\Theta)$ 2/3

-Values in the hygroscopic range

Moisture flow in the cup test includes both diffusive vapour flow and capillary flow. The division was made by assuming the water vapour diffusivity of a material to drop linearly from dry material value to zero as a function of relative water content. The difference to measured values was calculated as capillary flow.

$$g_l(\Theta) = g_{tot}(\Theta) - g_v(\Theta)$$



Liquid water conductivity function $K_l(\Theta)$ 3/3

-Adjustment with cup test simulation

Polynomial functions were fitted to the data to smoothen the functions and to acquire sufficient amount of data points for the material file. Relative water content step of 0.01 was used.

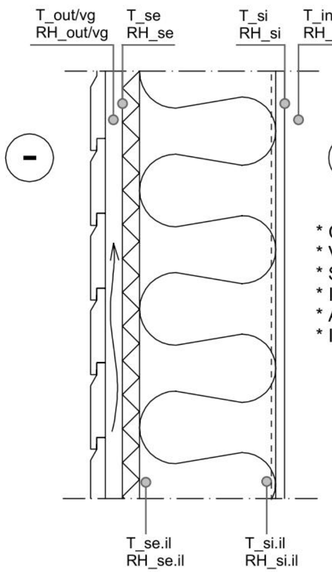
Material dependent parameter η_{sp} was iteratively adjusted until the wet cup simulation produced the measured value.

$$f_l(\Theta) = \frac{\Theta^{\eta_{sp}}}{\Theta^{\eta_{sp}} + (1-\Theta)^2 (1-\Theta^{\eta_{sp}})}$$

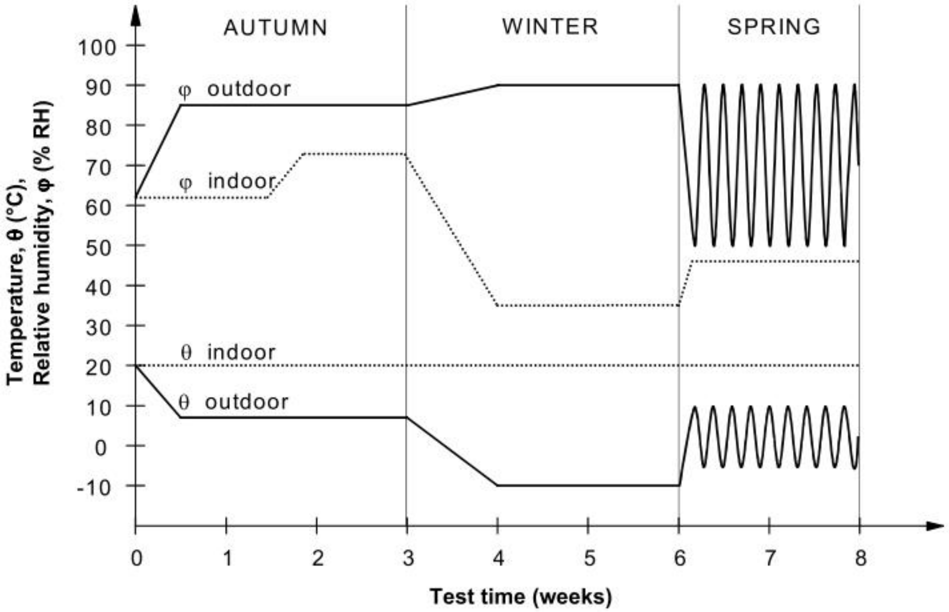
The values were fed to the program as:

$$\lg K_l(\Theta) = \log 10\left(f_l(\Theta) \cdot K_{rel}(\Theta)\right)$$

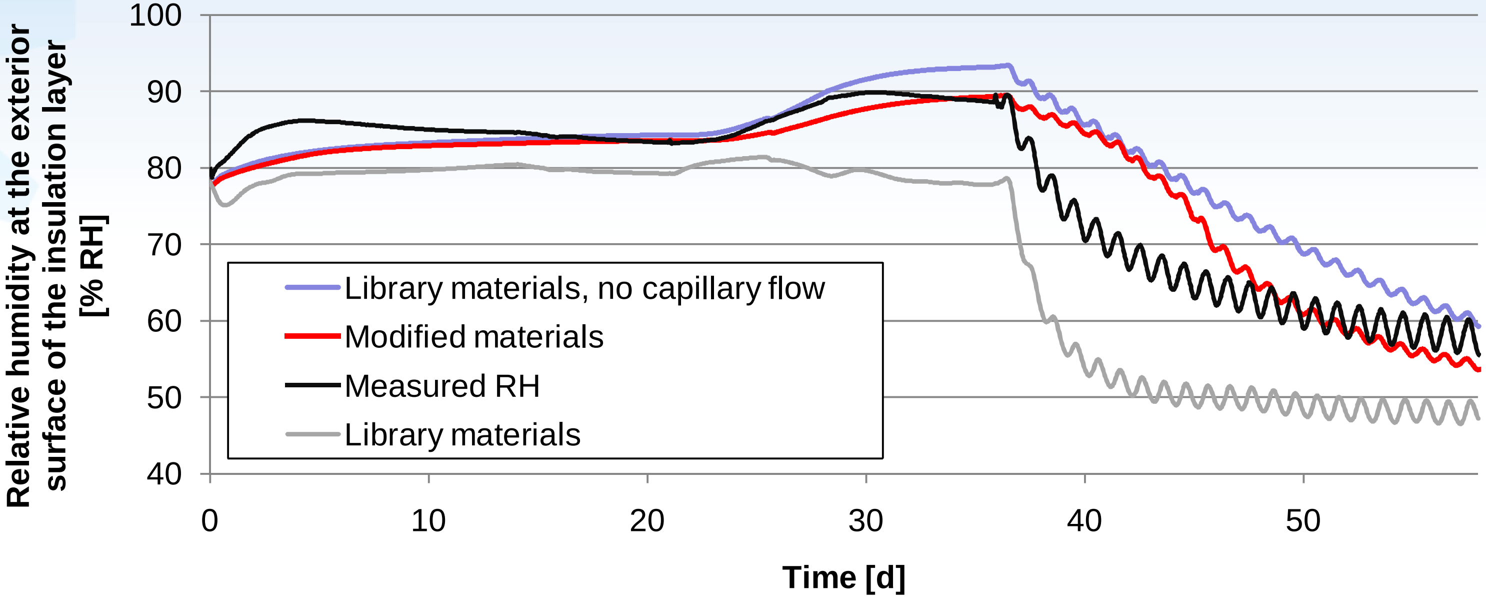
The assembly and the boundary conditions



* CLADDING (EXCLUDED IN THE CALCULATIONS)
* VENTILATION GAP
* SHEATING
* INSULATION LAYER
* AIR BARRIER
* INTERIOR LINING

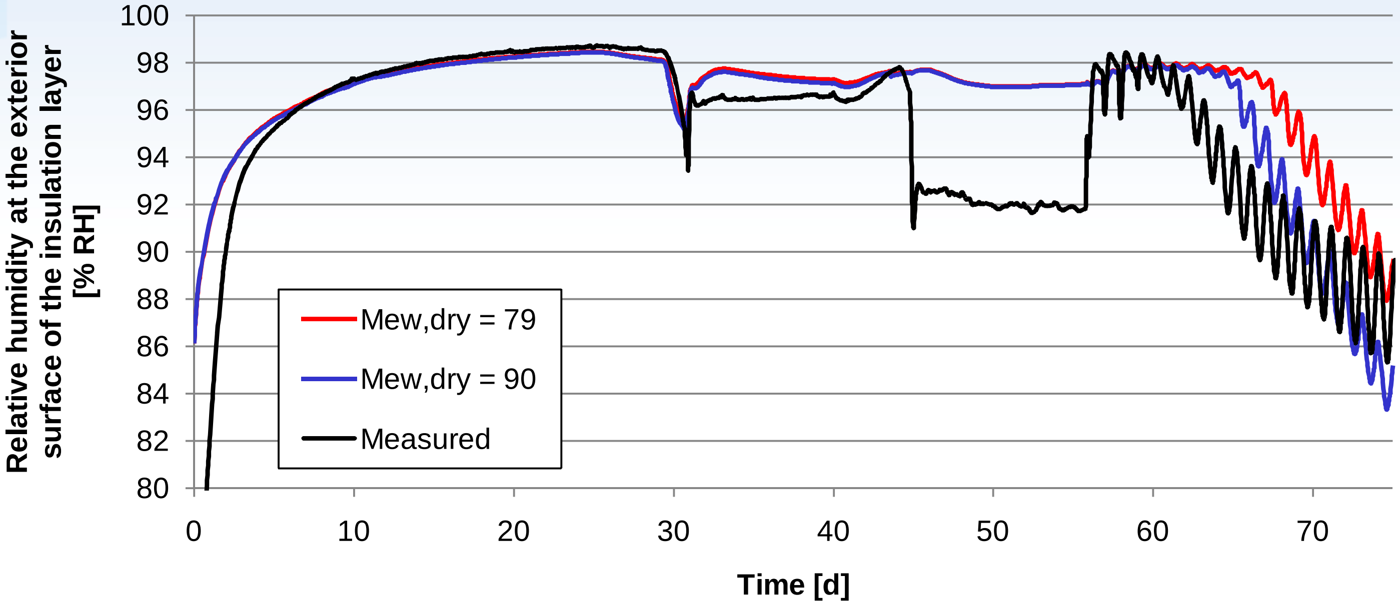


Relative humidity at the exterior surface of the insulation layer 1/3



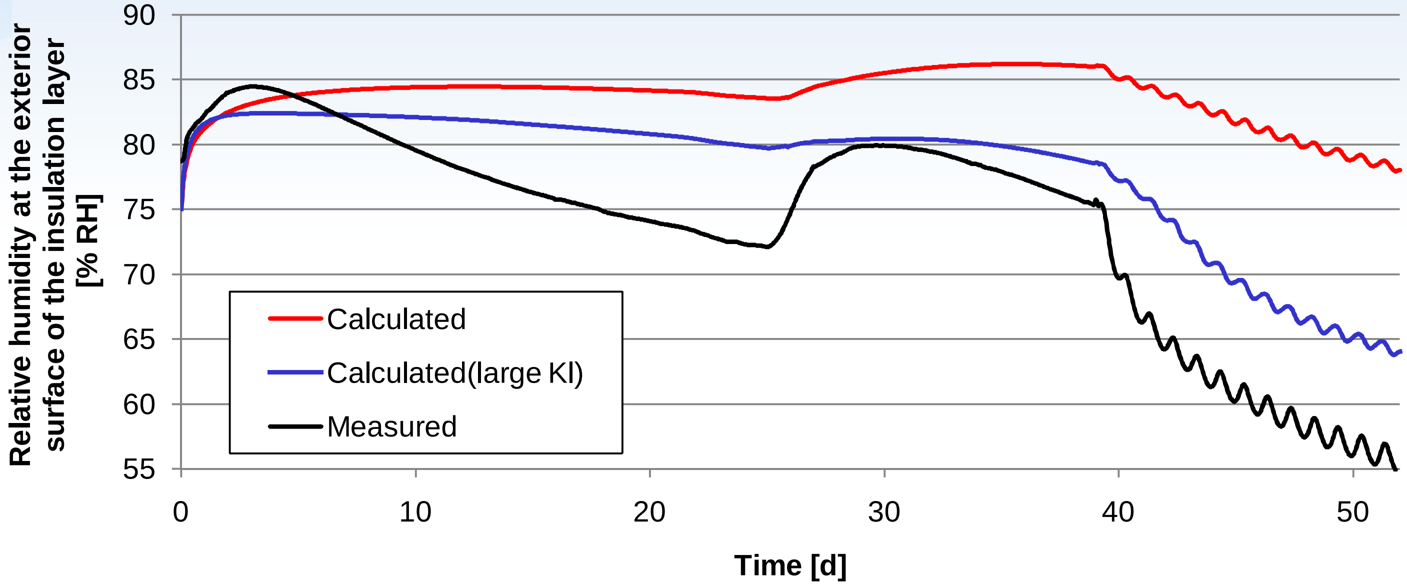
Increasing the liquid water conductivity of the sheathing lowered the relative humidity behind it. The non-modified wood fibreboard produced too low values of relative humidity in the simulation.

Relative humidity at the exterior surface of the insulation layer 2/3



The division of total moisture flow of the cup test into vapour and capillary fluxes affects the simulation results. Increasing the portion of capillary flow seems to improve the situation a little.

Relative humidity at the exterior surface of the insulation layer 3/3



The last example here has the biggest differences of all calculated cases. It had spruce plywood on both sides of the insulation.

Conclusions

- The procedure and the formulas are from the doctoral dissertation of Scheffler (2008) but the original procedure is more extensive
  - $K_{l,eff}$ wasn’t measured and no drying data was available so the calibration is not complete
- Material test results were in line with literature but it is possible that there are deficiencies in the initial values or laboratory set-up
- Wall assembly simulations with mineral wool and gypsum board (not presented here) had good results already with library materials. Adjusting material properties with simulation improved the results in the case with wood fibreboard.