Simulating school roof cavity

A BRANZ project measuring moisture in a school building roof cavity has helped refine the WUFI numerical simulation tool and identify shortfalls in knowledge. This will help designers create more realistic models and, ultimately, better buildings.

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INSTITUTIONAL BUILDINGS such as schools and halls have been in the spotlight recently because of potential moisture problems in their roof cavities.

Recipe for moisture

The high indoor humidity, air-permeable acoustic ceiling tiles and high R-value ceiling insulation in these buildings can lead to a significant amount of moist air reaching the cold steel of the roof structure.

Under these conditions, condensation can occur on cold clear nights when the dew point temperature is reached and the temperature of the roof cladding falls below the ambient temperature.

WUFI results help to change thinking

In recent years, BRANZ's WAVE programme has been using the WUFI numerical simulation tool to help develop remedial measures and alternative designs to counter these problems.

WUFI is a powerful tool, but it needs to be used with great care to obtain meaningful results. When describing the transport of air throughout a building, for example, there are assumptions and tweaks necessary to capture this dominant moisture transport mechanism.

Reality checked against modelling

As part of the WAVE research, an idealised WUFI model for a specific school roof design was compared with the real measurements.

The model used was created in an older version of WUFI2D, using a BRANZ ventilation module. This enabled the movement of air from the spaces below into the roof cavity to be modelled. This air movement is a significant contributor to roof space moisture.

The ventilation rates from the spaces below to the roof cavity were estimated based on previous fieldwork. Air movement across ceilings is a fundamentally important process that has inspired a new BRANZ project focused on the air permeance of ceiling linings to air movement.

School roof fitted with sensors

Wireless climate sensors capturing temperature and relative humidity were installed during the refurbishment of a school building north of Auckland.

This steel roof structure has timber thermal breaks between the purlins and the roof cladding.

Several sensors were placed in the roof cavity and additional sensors captured the indoor and outdoor climate.

Figure 1: Sensors in the roof measure temperature and humidity.

Collecting input data for simulation

Detailed ambient climate data for a specific location is generally not available. A building simulation often has to rely on assumptions for time-varying input parameters such as ambient temperature, humidity and radiation.

The first port of call is averaged yearly climate data from the nearest weather station.

In this case study we used data from NIWA for Auckland prepared as a typical meteorological year file – essentially a number of years are averaged to give a representative dataset.

Equally important is the indoor climate. In the absence of any detailed data, a simple approach is to use a daily sinusoidal oscillation of temperature and humidity superimposed onto a sinusoidal yearly variation.

However, these parameters are hugely dependent on occupant behaviour, and having measured data is a great help.

Using this basic approach – ambient climate from a weather station and an idealised sinusoidal indoor climate – WUFI can simulate, for instance, the relative humidity around the top of the steel rafter in the roof cavity (see Figure 1).

Good agreement between actual and simulated

Comparing the school roof simulated and measured data for the critical winter months reveals reasonably good agreement (see Figure 2). The mean measured value is about 5% higher than the simulated value.

The agreement becomes even better towards the end of winter. The higher readings in June might be caused by construction moisture being released after the cavity was sealed in.

The greater number of troughs and peaks in the simulated data is noticeable. These may be caused by underestimating the moisture buffer capacity of the roof structure components.

If we compare the indoor and outdoor climate data used in the model to the measured values, the original assumptions were fairly good. The average inside relative humidity assumed in the model over winter was 59%, and the measured value was slightly drier at 53%. The corresponding temperature figures were 19° and 17° respectively.

Next up, airflow through different ceilings

Our model has been able to predict the humidity around the steel members of the roof construction reasonably well, but some discrepancies remain.

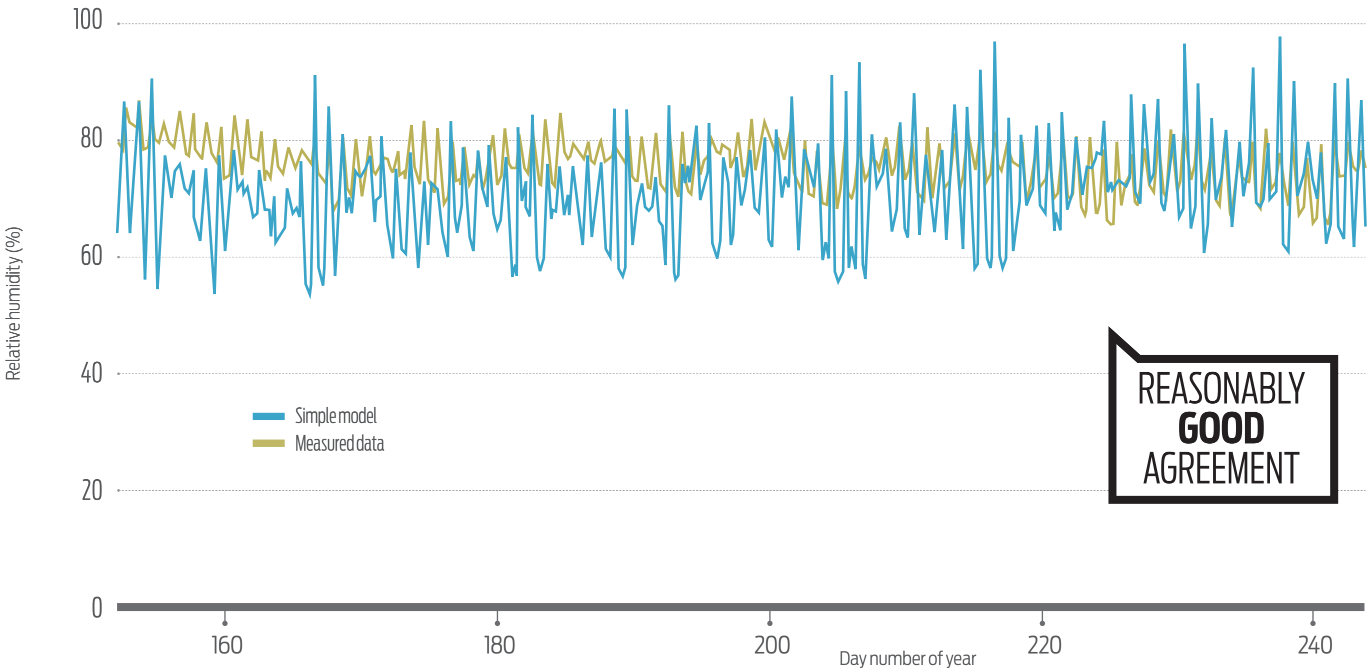

Figure 2: Comparison of school roof simulated and actual data.

The process of adequately capturing moisture transport via airflows across boundaries is one critical parameter to a successful model. BRANZ is currently working to characterise airflow resistances of different ceiling types, and these results will be published as they become available.

A better understanding of these ceiling airflow resistances as an input to WUFI simulations will help designers and consultants to create more realistic models and ultimately lead to better building design.

Available for industry to use

The ventilation module used to simulate the air movement in this school building is available in newer versions of WUFI to commercial licence holders. It does require a greater level of information from the user to be used effectively.

The key to this is knowing the amount of air movement and having a solid understanding of the indoor conditions. The new BRANZ roof permeance project and the WUFI development project (see pages 52-53) will provide further insight and address these issues.