Roof ventilation

BRANZ physicists have developed a useful calculation for designers to work out the minimum number and area of vents required in roof spaces.

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THE ARTICLE *Vents in skillion roofs* in *Build* 155, pages 78-80, discussed the placement of vents for skillion roof ventilation in low wind zones.

Here, we work through an example to show the principles used to estimate the minimum number of ventilation openings required when there is little wind.

Worked example for a small room

This example could be a smaller classroom (40 m²) with an average ceiling height of 3 m. Many parameters have an impact on the roof space climate and ventilation requirements (see Figure 1), but we will only consider the most important.

Local climatic conditions

During the design process, it is necessary to look at the indoor climate, determined by the use of the building, and the prevalent climatic conditions – wind, temperature and humidity – at the site.

Indoor climate

For the indoor climate, we will assume a room temperature of 22°C and a relative humidity of 65%. We have measured this multiple times in school classrooms and residential buildings.

Outdoor climate

Next is the outdoor climate, which is highly variable. The condition selected for this calculation needs to reflect that the worst

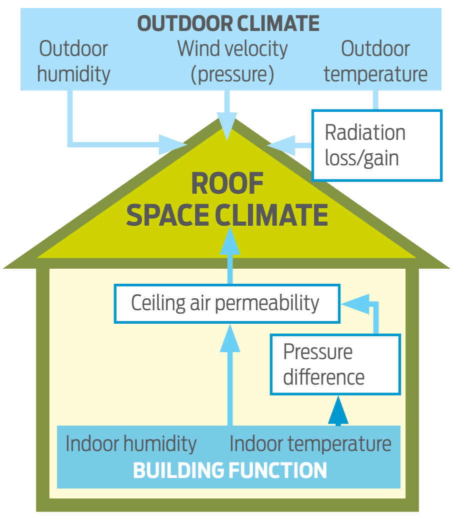

Figure 1: Parameters influencing the roof space climate.

weather conditions last for only a few days. Conditions are available for some regions in BRANZ study report SR343, page 19, Table H.

For this calculation, we assume:

- the outdoor temperature is 12°C with a relative humidity of 75%
- there is a light wind of 2 m/s
- the roof space air temperature is the same as the outdoors.

Strictly speaking, this is not the case, but it is fine for this calculation. If the room under the roof is heated, the roof space air temperature is a few degrees higher than outdoors, or at night, the roof space air could be colder than the outdoor temperature, due to overcooling of the roof cladding.

Psychometrics

While relative humidity is common when talking about moist air, using vapour pressure instead allows for easier calculation. The psychrometric chart (see Figure 2) conveys the relationship between relative humidity, temperature and vapour pressure.

Coming to terms with condensation, in *Build* 144, pages 71-72, has a detailed description of its use. The chart only has the graphs for the four relative humidities of interest in this example – 65%, 75%, 90% (threshold) and 100% (saturation).

For this example, determine the vapour pressure indoors by starting at the indoor temperature of 22°C and follow the line up to the relative humidity indoors (65% graph). Moving to the left, read the vapour pressure for this temperature/relative humidity condition – about 1,700 Pa. Repeat this for the outdoor condition and the threshold to determine their vapour pressures.

From the chart, the vapour pressure:

- for 65% RH at 22°C is 1,720 Pa
- for 75% RH at 12°C is 1,050 Pa
- for 90% RH at 12°C is 1,260 Pa.

The saturation pressure is 1,400 Pa.

The graph also shows that the vapour pressure of the room air is higher than the saturation pressure (100% RH) at the roof temperature. Therefore, the moisture of the room air will condense when transported into the roof cavity.

Pressures

The pressure inside the room is predominantly stack-driven by the temperature/density difference of the air, the height of the room and the wind-induced negative-pressure in the roof.

The pressure difference is usually between 1 and 4 Pa.

Prevailing wind

For this calculation example, we assumed an average wind speed of 2 m/s at the height of the eaves, which will induce a pressure of about 1.5 Pa at the eaves.

Airflow through the vent

For the vent, we consider a round soffit vent with a diameter of 65 mm. This type allows an airflow of about 3 l/s at the pressure of 1.5 Pa.

Another ventilation opening is a narrow slot of 15 mm width at the eaves, which provides an airflow of 13 l/s per linear metre.

Air permeability of ceiling

The air permeability of ceiling material/construction and light fixtures have been measured and will be published in *Build* 158. For this example, we use the acoustic ceiling tiles. This type of ceiling has an air permeability of around 0.7 l/m² s at a pressure difference of 1.5 Pa.

Summary of parameters

The parameters set for this example are:

- outdoor climate - temperature 12°C, relative humidity 75%, wind speed 2 m/s
- indoor climate - temperature 22°C, relative humidity 65%
- ceiling air permeability - 0.7 l/m² s at 1.5 Pa pressure difference
- wind pressure at eaves for a prevailing wind at 2 m/s - 1.5 Pa
- vent airflows - 3 l/s or 13 l/s per linear metre.

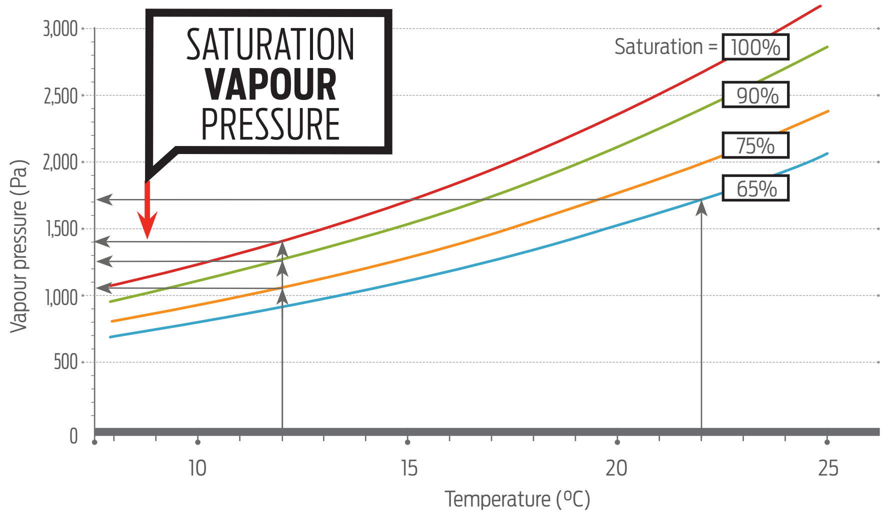

Figure 2: Psychometric chart.

Calculating the required airflow

We can now work out the ventilation needed.

First, calculate the mixing ratio of the indoor and the outdoor air. This is so the roof saturation condition (100% RH, 1,400 Pa) is not reached but stays at or below the set threshold level of 1,260 Pa in our example. We then multiply this by the airflow through the ceiling (30 l/s).

$$\frac{\left(\text{indoor vapour pressure} - \text{threshold pressure}\right)}{\left(\text{threshold pressure} - \text{outdoor pressure}\right)} \times \text{ceiling airflow}$$

Using the example values:

$$\frac{(1{,}720 - 1{,}260)}{(1{,}260 - 1{,}050)} \times 30 \approx 66$$

What does the result mean?

In this example, a ventilation airflow of about 66 l/s is needed to not exceed 90% relative humidity. This can be achieved with either 22 of the 65 mm round soffit vents or at least 5 linear m of 15 mm ventilation openings at each side of the building.

When the outdoor air vapour pressure approaches the threshold (in this example, 90% RH or 1,260 Pa), more airflow is required to keep the roof vapour pressure below the moisture limit.

Such airflows will be impractical or impossible to achieve, and other design parameters, such as a less air-permeable ceiling, need to be considered to achieve the goal.

Note Most of the information in the example can be derived or estimated or will be available in future BRANZ publications. The airflow coefficients of light fixtures and ceiling linings will be published in *Build 158*.

Skillion roofs

Skillion roofs are particularly vulnerable to moisture accumulation.

Consider a skillion roof with an area of 45 m². This has a cavity air volume of 3 m³. Assuming the air permeability of the ceiling allows an airflow of just 5 l/s, the cavity is filled from the room below in 10 minutes.

Compare this to a gable roof with the same area and a ridge height of 1.4 m. Its volume would take 1 hour and 40 minutes to fill – ample time to dilute the moist air from the room even if outdoor air infiltration entering the roof is slow.

The gable roof is just more robust at managing moisture than a skillion roof. Its larger cavity volume, and therefore capacity, can store much more moisture under the same conditions.