

# Airflow through ceilings

How airtight is a ceiling? Does it need to be airtight? What if it isn't? BRANZ has answers after testing the air permeability of different ceiling types.



Airtight room at BRANZ before ceiling panels added.

**WE HAVE** discussed roof spaces several times in *Build* lately, including what the potential moisture-related problems are and what to do about them.

## **Condensation and roof cavities**

In *Roof ventilation* on pages 57-58 of *Build 157*, there was an example of how to calculate ventilation opening requirements to minimise the risk of damaging condensation.

We highlighted that a roof space cannot be viewed in isolation. External climate, exposure to wind, occupant behaviour and the indoor climate all play a role in determining if the space under the roof cladding will have moisture-related problems.

## **Ceiling separates different spaces**

The ceiling is another important piece of the puzzle. In the common cold roof design, insulation placed above the ceiling lining separates two very different climates:

- The living area below the ceiling, which we try to keep comfortable and at an even temperature year round.
- The roof space above the ceiling, which can become very hot on sunny days and very cold on clear nights (running the risk of condensation).

## **Moisture carried through ceilings**

Stack effect and wind action across the building envelope typically results in a pressure gradient of a few pascals across the ceiling. This draws air from the living areas upwards into the roof cavity.

Indoor air typically carries more moisture and should be prevented from getting into the roof space. If it reaches the cold roof deck surface when it is at or below the dew point temperature, water vapour in the air will turn into water droplets.

### The science of measuring air permeability

For a scientific approach to understanding the frequently fine balance between having moisture problems in the roof space or not, knowledge of the air permeability of ceilings and ceiling fixtures is essential.

Air permeability through the ceiling can be described using the simple formula:

$$Q = C \Delta P^n$$

where

Q is the volumetric airflow per time interval

C is the flow coefficient characteristic for the ceiling/fixture

$\Delta P$  is the pressure difference across the ceiling

n is the coefficient describing the nature of the flow, going from laminar (non-turbulent) to turbulent.

Ceiling characterisation is performed in a specially constructed room with airtight walls. Air is pumped into the room at a known rate (parameter Q) while the pressure difference ( $\Delta P$ ) across the ceiling is recorded.

By doing this for several different parameter pairs (Q and  $\Delta P$ ), we obtain data to derive the characteristic ceiling-specific constants C and n. The results are normalised per square metre of ceiling or, where applicable, per linear metre of joint.

### Testing different ceilings at BRANZ

BRANZ has started measuring the air permeability of different ceiling types and fixtures. So far, four ceiling types have been tested:

- Acoustic tiles, used in offices and classrooms.
- Plasterboard with scotia and expansion joint.
- Plywood panel ceiling with and without gap (5 mm) between boards.
- Tongue and groove (T&G) timber ceiling.

The BRANZ test room ceiling was lined with these four materials and the airflow determined. The ceiling area measures 38 m<sup>2</sup>, which is large enough to account for variations.

### Acoustic tile ceilings very permeable

Table 1 shows the average airflow values accounting for measurement, material and workmanship variations. These are for a 4 pascals difference between the room and the roof cavity. The formula above can be used to determine airflows at any given pressure difference.

The leakages are expressed in litres of air per second per square metre of ceiling or, where appropriate, in cubic metres per hour per linear metre. The latter is useful for ceilings where the leakage occurs on the perimeter of larger panels with high airflow resistance, for example, plasterboard with scotia or acoustic tiles.

Interestingly, Table 1 shows the air permeability of acoustic tiles is an order of magnitude larger than that through a T&G timber ceiling. An air barrier is recommended for T&G ceilings to restrict

air movement through the ceiling. It is not practical to install an air barrier on suspended acoustic tile ceilings, hence these systems provide little resistance to airflow across them.

### Factor in ceiling penetrations

Penetrations through the ceiling such as cables, pipes or light fittings add to the overall air permeability and need to be considered too.

Table 1 also shows airflows through light fittings ranging from an old light bulb fitting to halogen and modern LED-based fittings. Modern downlights clearly offer significant advantages in restricting the airflow.

### Useful to evaluate specific design

The explicit numbers in Table 1 may only be useful to professionals evaluating a specific design performance. However, they illustrate the large differences in air permeability of various ceiling types and the significant influence penetrations can have.

We intend to add to the database, so if you would like us to look at a particular ceiling type or fitting, feel free to get in touch. ◀

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**Table 1**

## Air permeability of different ceiling types and light fittings

CEILING TYPE	AIRFLOW Q (l/sm <sup>2</sup> )	AIRFLOW Q (m <sup>3</sup> /hm)
Acoustic tiles	2.0	2.2
T&G timber ceiling	0.2	–
Plywood 12 mm with 5 mm gap	0.14	0.3
Plywood 12 mm	0.03	–
Plasterboard with scotia	–	0.17
Control joint	–	0.25
LIGHT FITTING TYPE	AIRFLOW Q (l/s)	
Incandescent downlight old style	3.0	–
Incandescent downlight new style	0.9	–
Halogen downlight	0.15	–
LED downlight, modern design	0.04	–

Table Amended 21 Feb 2017