

# ROOF ACOUSTIC PERFORMANCE



# NOISE ATTENUATION



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External sounds (noise) penetrate houses through windows, doors, walls and roof. Usually the roof is the least important path of noise admission. However, on sites under a flight path near an airport, or where there is a busy road or railway nearby, perhaps on higher ground, roof design for sound attenuation (noise control) becomes important.

## SOUND FUNDAMENTALS

‘Sound’ is the basic word for anything acoustic, it is generally used in a pleasant context, like; “The sound of the sea”. The word ‘noise’ usually refers to unpleasant sound that reduces the quality of life. So the sound of an aircraft overhead on takeoff or landing is referred to as ‘aircraft noise’. To limit the level of aircraft noise inside a house the roof is a key factor. All elements of the roof play a part in limiting noise, the external cladding of tiles or metal sheeting, the foil sarking, the air space above the ceiling, the insulation and the ceiling material, but the most crucial single item is generally the external roofing material

### ◆ Sound Attenuation

As sound penetrates any material its intensity diminished with distance.

The original sound is also weakened by scattering and absorption within the material it passes through.

These combined effects are called sound (or noise) attenuation. While there have been many acoustic tests carried out to measure the sound attenuation of building materials the results can only be applied to real house situations in general terms.

For any specific roof with certain outer material, sarking, space, insulation and ceiling can be built; there are many other variables that impact on acoustic performance.

These include roof penetrations, eaves width, window size and orientation, type of glazing, window and door seals, interior surface finishes, and surrounding ground cover (hard paving reflects rather than absorbs sounds).

Then, there is variability in the aircraft noise itself.

In the 1960s when jet passenger aircraft became common in Australian skies a Boeing 707 or 727 generated takeoff noise at 500 metres of up to 115dB(A).

With development of aircraft and their engines, the maximum aircraft noise levels at 500 metres are now 95dB(A) and the next generation jet passenger aircraft promise noise levels in the 90 to 92dB(A) range at 500m altitude, this is combined with a steeper angle of climb which reduces the area of the noise footprint.

These figures are all for takeoff, when noise levels are highest, when landing the levels are 15 to 20dB(A) less.



The Committee on Aviation Environmental Protection (Controlling authority for the European and North American air transport industry) has recommended maximum noise levels as low as 55dB day/night for aircraft designed after 2006 and both the EU and US industry are working toward this limit.

Further variations of noise levels are influenced by the direction sound travels between an aircraft and a house, it first comes toward the house, then is above it, then goes away, or it may be off to the side at varying distances and angles from a house.

Then too weather conditions, mainly wind and rain, alter the noise levels of aircraft. So to give a definitive figure for sound attenuation of aircraft, or any moving external noise source, inside a house is not sensible.

It is possible however, to specify a roof construction that is conventional, economic, and optimizes acoustic performance in respect to traffic noises such as aircraft.

### ◆ **Sound Measurement**

Sound is measured in a logarithmic scale with the decibel (dB) as the unit.

Acoustic measuring equipment has a correction factor to reflect the sensitivity of the human ear; this is known as the 'A-weight'.

To indicate this, the letter 'A' is added and the decibel abbreviation so it becomes dB(A). In a quiet library the sound level is about 35dB(A), in an open-plan office (now with quiet electronic keyboards) background noise is 55 to 60dB(A), heavy truck noise is about 90dB(A).

Vibrating objects produce sound. Sound wave vibrations have a broad range of frequencies measured by Hertz (Hz).

Typical noise from heavy road, rail, or air traffic is in a broad range of 100 Hz to 3000 Hz. Considering just the external roof cladding, tiles have a sound reduction potential of 25dB(A) for terra cotta units and 30dB(A) for concrete units, while a sheet steel roof cladding reduces sound in the traffic frequencies by 12dB(A).

Airservices Australia have acoustic monitors permanently set up in the flight path 'footprint' of nine of the busiest airports (Cairns, Brisbane, Gold Coast, Sydney, Canberra, Melbourne, Essendon, Adelaide and Perth). Typical aircraft noise levels detected by these monitors are in the range of 65 to 95dB(A).



## RECOMMENDED NOISE ATTENUATION PERFORMANCE FOR A HOUSE

The Building Code of Australia (BCA) has no sound insulation requirements for house roofing, but gives specific requirements (in Vol. 2 P2.4.6) for party walls separating dwellings.

These “must provide insulation against the transmission of airborne sound sufficient to prevent illness or loss of amenity to the occupants.”

To quantify this goal the BCA in 3.8.6.2 Sound insulation requirements, states that the separating wall between dwellings must “achieve the Weighted Sound Reduction Index with Spectrum Adaption ( $R_w + C_{tr}$ )... of 50 for wet areas and habitable rooms with discontinuous construction (a cavity wall).

This is a necessarily high requirement to allow for sustained, long term, or impact noise.

While there is no BCA requirement for sound insulation of a roof, it could be implied that a sound reduction  $R_w + C_{tr}$  of 40 would “prevent illness or loss of amenity to the occupants” from intermittent aircraft noise. But, at critical sites (under takeoff areas) of the flight path footprint of airports an  $R_w + C_{tr}$  of 50 is recommended.

There is the Weighted Sound Index ( $R_w$ ) for laboratory test measurements defined in Australian Standard AS/NZS ISO 717-1 (2004) Acoustics – Rating of sound insulation in buildings and of building elements – Airborne sound insulation (2004).

This  $R_w$  figure is a weighted index, which is useful to predict attenuation of audible sound frequencies, but low frequencies are not well accommodated.

While the Weighted Sound Reduction Index with Spectrum Adaption ( $R_w + C_{tr}$ ) is a useful prediction measure for a range of audible sound frequencies including low frequency, the basic Weighted Sound Index ( $R_w$ ) is applicable for high frequency sounds, such as jet aircraft engines.

When designing a roof to limit airborne sound transmission both  $R_w$  and  $R_w + C_{tr}$  figures need to be considered. The  $R_w$  figure applies to jet aircraft noise, the  $R_w + C_{tr}$  figure applies to mid-to-low frequency sound, such as heavy traffic noise and non-jet aircraft, especially helicopters.

## RELATIVE PERFORMANCE OF HOUSE ROOFING MATERIALS

As about 95% of Australian houses are roofed with sheet metal or tiles the basic roof construction with each of these materials is a reasonable comparison, where external noise attenuation (including aircraft noise) is concerned.

As foil sarking, thermal insulation and ceiling material influence noise attenuation, these factors need to be equalized so the comparison of roofing materials is valid.

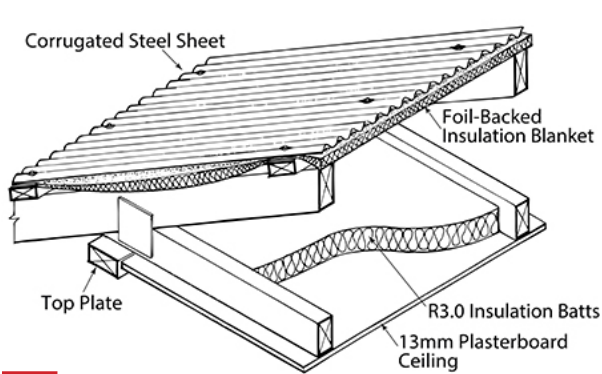
Four examples give an indicative comparison between sheet metal and tiles. The first pair is conventional construction with standard ceilings and typical thermal insulation.



The second pair of examples have an upgraded ceiling, with a dense plasterboard (30% higher density e.g. Boral 'ENVIRO SoundSTOP' or CSR GYPROCK 'SOUNDCHEK') fixed to furring channels, to improve noise attenuation of the roof/ceiling system.

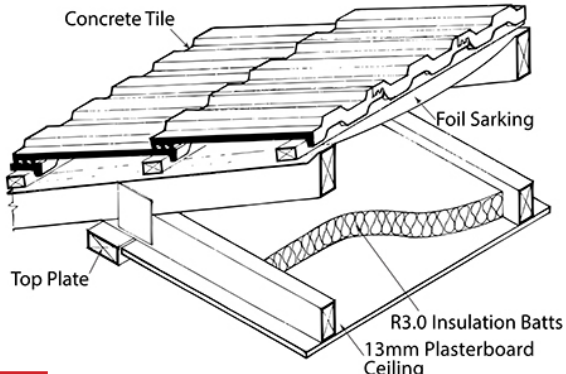
All four examples have roof and ceiling framing at 600mm centres with R3.0 insulation batts above the ceiling.

**Four drawings here:**



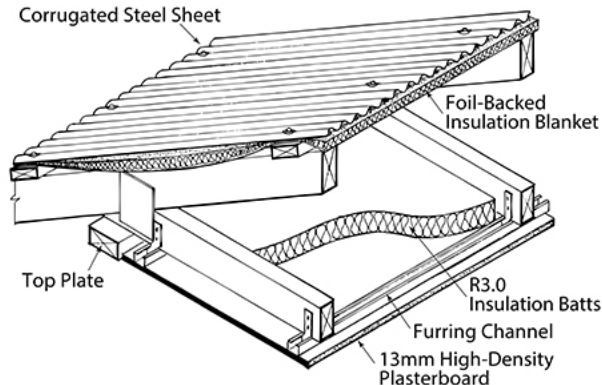
**1**

Sheet steel roofing, with foil/insulation blanket over battens. 13mm thick plasterboard ceiling fixed to ceiling rafters.  $R_w = 43$   $R_w + C_{tr} = 33$



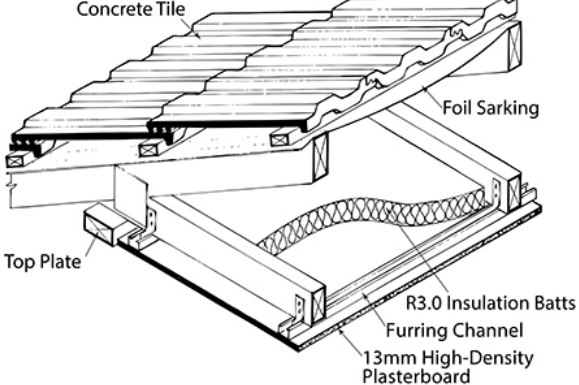
**2**

Concrete tile roofing, with foil sarking under battens. 13mm thick plasterboard ceiling fixed to ceiling rafters.  $R_w = 43$   $R_w + C_{tr} = 37$



**3**

Sheet steel roofing, with foil/insulation blanket over. 13mm thick dense plasterboard on steel furring channels.  $R_w = 51$   $R_w + C_{tr} = 42$



**4**

Concrete tile roofing, with foil sarking under battens. 13mm thick dense plasterboard on steel furring channels.  $R_w = 52$   $R_w + C_{tr} = 46$



Consistently, test figures show equal, or slightly improved roof noise attenuation performance for tiles compared to sheet steel for the Weighted Sound Index (Rw) and a significant improvement (9% to 12%) for tiles compared to sheet steel for the Weighted Sound Index with Spectrum Adaption (Rw + Ctr).

Also evident from acoustic tests is that houses subject to either significant aircraft, or other airborne noise should optimize material selection and installation detail to achieve acceptable noise attenuation levels.

This means selecting tiles (concrete or terra cotta) for roofing, then using furring channels to attach a ceiling with one or more layers of high density plasterboard ('SoundSTOP' or 'SOUNDCHEK').

Using the same construction as example 4 above, only substituting 2x10mm thick layers of high density plasterboard for the ceiling, will give Rw / Rw + Ctr figures of 58/50, representing a very satisfactory acoustic performance for a house roof in an aircraft noise footprint.

***Factors to maximize noise attenuation for a house (or any building) in a noisy environment can be categorized in three areas as follows:-***

## **ROOF/CEILING**

- ◆ **Select tiles for roofing.**
- ◆ **Foil sarking, slightly draped under battens.**
- ◆ **Air space and R3.0 insulation batts above ceiling (higher R values do not add to noise attenuation performance measurably).**
- ◆ **Fix ceiling on steel furring channels beneath ceiling rafters.**
- ◆ **High density plasterboard in one or more layers for ceiling lining.**
- ◆ **Design wide eaves, or tiled window awnings, to acoustically 'shade' openings.**
- ◆ **Design extensions of the main tiled roof to cover patios and verandahs.**
- ◆ **Limit roof penetrations and where necessary, flash them well with sheet lead.**

## **SURROUNDINGS**

- ◆ **Consider masonry screen walls beyond large window/door openings.**
- ◆ **Have as much soft landscaping as possible near openings in walls.**
- ◆ **For hard paved areas, extend the house roof to acoustically 'shade' pavements.**



## WALLING/WINDOWS

- ◆ **Masonry external walls, preferably cavity masonry.**
- ◆ **Use windows and doors with good sealing around frames and at openings.**
- ◆ **Specify thick glazing (5mm minimum) or double glazing.**
- ◆ **Heavy curtains for windows (plus soft interior finishes).**

## REFERENCES

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