DECRA® METAL ROOFING

TECHNICAL NOTE

SOUND ATTENUATION OF ROOF CLADDINGS AND SYSTEMS

Executive Summary

There have been cases where specialists have attempted to increase the sound attenuation of lightweight roofs by adding plywood sarking under the lightweight claddings.
Common New Zealand roof cladding materials and complete roof and ceiling structures, including fibreglass bulk insulation and plasterboard, were tested for NZMRM Inc. to international standards for noise attenuation properties at the University of Canterbury. The testing concluded that:

- When full roof/ceiling systems are taken into account there is little difference between cladding types and therefore no reason to treat roof claddings differently when designing for noise control .
- Different roof claddings vary to some extent in attenuation properties when measured in isolation but the roof cladding appears to have little influence on the overall roof/ceiling system.
- Additional mass made some difference to a full roof/ceiling system but was not justified by the additional cost. Use of roof underlay does improve the noise attenuation by concrete tiles.
- The greatest influence on noise attenuation to the interior of dwellings is at ceiling level.
- Given that both airborne and structure borne noise will enter the roof/ceiling cavity to varying degrees, it is also clear that sound absorption in the cavity plays a significant role. The addition of extra fibreglass insulation was shown to have the greatest influence with the least cost and enhanced thermal insulation benefits.

Background

As cities expand and the close proximity of dwellings to major roads and airports becomes more common, the need for good sound attenuation design of residential dwellings becomes more and more important. Some regulatory authorities now require a maximum allowable noise level at night in bedrooms, which are generally located immediately underneath the ceiling in both single and two storey houses.
Internationally, New Zealand has a high percentage of light weight metal roofs installed compared to heavy clay or concrete tile roofs. This preference for light metal roofs is likely to increase as people seek to minimise damage caused by heavy roof materials in earthquake zones where they have proven to be one of the more destructive building components.

A number of studies have been carried out around the world and in New Zealand relating to exterior and interior wall sound insulation but the literature survey that was Phase 1 of this research project showed that very little has been carried out on roof claddings and composite roof constructions. Historically, acoustic engineers have generally relied on applying a mass law and reference to similar wall constructions for absorption, damping and any other influences likely to affect noise transmission.

Apart from mass, good sound attenuation through walls relies heavily on separation or partial separation of structures and air tightness. Roof structures and claddings are such that these features are difficult to achieve and expensive to construct.
NZ Metal Roofing Manufacturers Inc. developed a research project with the university of Canterbury Acoustic Research Group to investigate noise attenuation through the roof structure. This research was part funded by TechNZ, without whose assistance it would not have been carried out. A significant part of the ground work in Christchurch was done by Gerard Roofs local staff members.

The first two phases of this major study have now been completed. Phase 1 was the literature survey and Phase 2 the laboratory study. Phase 2 was divided into two parts; Part 1 was materials only and Part 2 was structures. Phase 2 quantifies the effects of a variety of common roof constructions, materials and most importantly cladding types, in sound insulation of interior spaces of dwellings.

There have been cases where specialists have attempted to increase the sound attenuation of lightweight roofs by adding plywood sarking under the lightweight claddings.
This study was designed to investigate if the sarking of lightweight and heavyweight roofs technically or economically makes a difference to sound attenuation in common roof structures.

Testing & Results

In order to identify the main influences on attenuation, two separate sets of tests were carried out. These were laboratory tests on a variety of base roof types (Phase 2 Part 1) and measured sound reduction through typical pitched roofs and replicated common truss construction (Phase 2 Part 2).

All these tests were carried out on a simulated 27° pitch roof located between two test rooms otherwise separated by a solid concrete wall. In the room facing the roof a standardised noise source was located and on the other side (“under the ceiling”) the sound measurement devices were located.

Firstly, the roof claddings alone were tested. These results (Table 1) clearly show that, in isolation, metal roofs perform better than heavy concrete tile roofs without underlay. However, the addition of underlay did improve the performance of concrete tile roofs. Air tightness (sound leakage) was clearly the main influence to differences where, without underlay, poorly fitting concrete tiles offer an easy path for sound leakage. The addition of the mass of plywood also increased performance of metal roof claddings, probably by the mass dampening transmitted noise, as expected.

Cladding	Single Number Ratings		
	STC	RI,w	DI,n,w
Metal Tile – Paint	16	16	15
Metal Tile – Chip	16	16	16
Metal Tile – Chip with Underlay	18	18	17
Longrun 0.4	17	17	17
Longrun 0.55	18	18	17
Corrugate 0.4	19	19	19
Corrugate 0.4 with 17.5 mm Ply	25	25	24
Concrete Tile	15	16	16
Concrete Tile with Underlay	21	21	20

Table 1. Roof Cladding Results

Calculation	Symbol	Reference Standard
STC Rating	STC	ASTM E 413 - 04
Weighted Intensity Sound Reduction Index	RI,w	AS/NZS ISO 717-1:2004
Weighted Intensity Normalized Level Difference	DI,n,w	AS/NZS ISO 717-1:2004

Table 2. Single Number Ratings Definitions

The complete roof/cavity/ceiling systems were then tested. The base system was taken as roof cladding, underlay if required, standard bulk insulation (fibreglass) and GIB® plasterboard ceiling. These are shown in **Table 3**.

System - Cladding	Single Number Ratings		
	STC	RI,w	DI,n,w
Standard – Corrugate 0.4	47	45	45
Standard – Metal Tile (Chip)	46	45	44
Standard – Concrete (No Underlay)	46	45	45
Standard – Concrete with Underlay	46	46	45
Sarking – Corrugate 0.4	47	46	45
Sarking – Metal Tile (Chip)	48	47	46
Sarking – Concrete (No Underlay)	47	46	46
Sarking – Concrete with Underlay	48	47	46

Table 3. Roof/Ceiling Base System Results

These results are in contrast to the roof cladding only. The full system results varied by just a single STC point between cladding types with no difference between steel tile and concrete tile and only up to 2 STC difference with the addition of plywood sarking.

An examination of a number of variations to the base system were then examined to determine the most cost-effective way to reduce roof-transmitted noise. There will always be situations where it is necessary to reduce external noise transmitted through the roof and the testing had shown that there is little difference between different roof claddings in a roof/cavity/ceiling structure.

	Base System	Modification of the ceiling linings	Modification of the ceiling linings	Addition of the plywood sarking	Double thickness fibreglass
Trusses	Dressed 70x50 pinus radiata H1.2 trusses, 27° pitch, 900mm centres				
Sarking	No	No	No	17.5 mm treated CD plywood	No
Sound absorbing material	Pink® Batt® Classic R3.6 180mm thick	Pink® Batt® Classic R3.6 180mm thick	Pink® Batt® Classic R3.6 180mm thick	Pink® Batt® Classic R3.6 180mm thick	2 layers of Pink® Batt® Classic R3.6 each 180mm thick
Ceiling	13 mm GIB® Standard (8.5kg/m2)	13 mm GIB® Noiseline® (12.4kg/m2)	10mm+ 13 mm GIB® Standard (15.3kg/m2)	13 mm GIB® Standard (8.5kg/m2)	13 mm GIB® Standard (8.5kg/m2)

Table 4. Roof/Ceiling System Configurations
Note: All metal roofs have roof underlay after the initial tests because this is required by the NZBC and is always fitted.

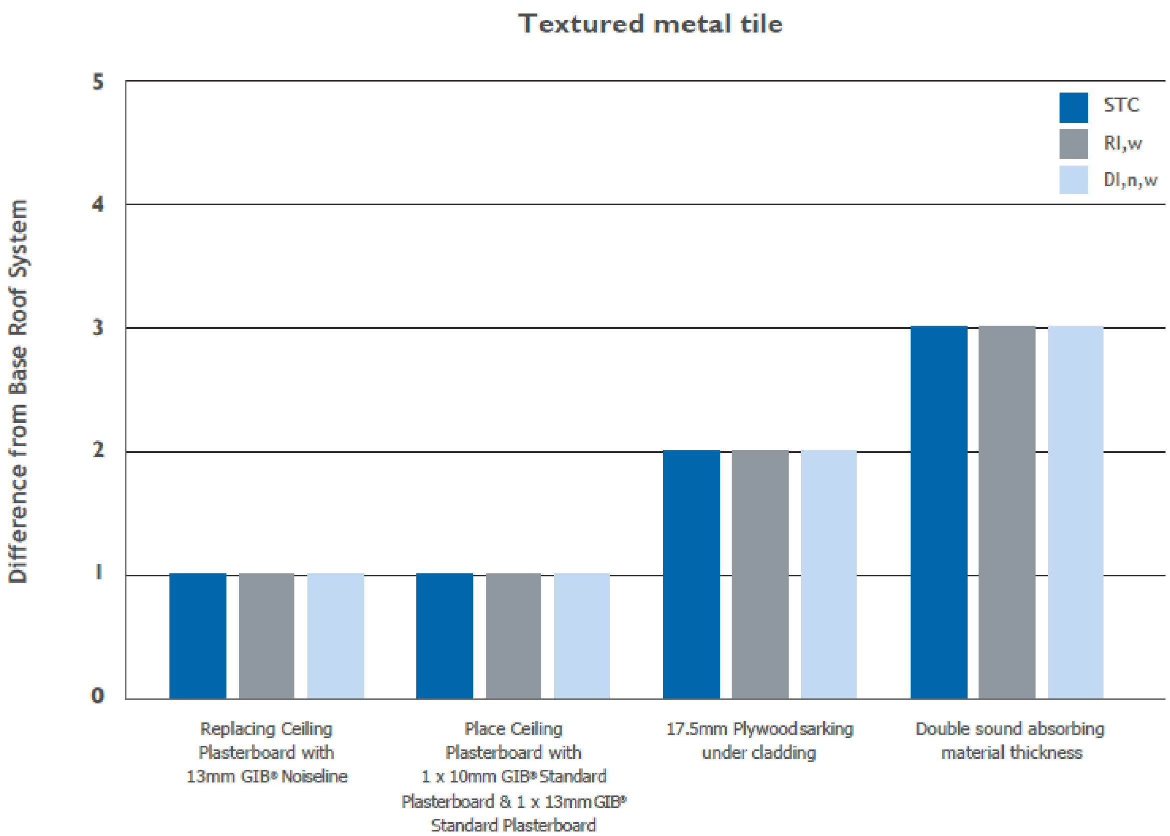

Figure 1. Differences from Base System for Textured Metal Tile

Figure 1 summarises the results for textured metal tiles. Report No. 72 (See References) includes tables showing the results for each of these variations for a number of different roof claddings. In New Zealand the cost difference between utilising 17.5mm ply sarking compared with double the fibreglass insulation is triple.

Conclusions

- When full roof/ceiling systems are taken into account there is little or no difference between roof types and therefore no reason to treat roof types differently when designing for noise control
- Although roof claddings vary noticeably when measured in isolation, the roof cladding alone has little influence on the overall system of roof, roof cavity and insulated ceiling.
- Addition of mass or attempts to make the roof airtight at the roof line with plywood or roof underlay makes little difference if any to a full roof/ceiling system.
- The use of underlay with concrete tiles does significantly improve their performance.
- Given that both airborne and structure borne noise will enter the roof/ceiling cavity to varying degrees, it is also clear that sound absorption in the cavity plays a significant role. The addition of fibre glass insulation above the ceiling is shown to have the greatest influence of the variants tested, at the least cost.

References

- Report No.70 Version 1.0 31/7/2009 Noise Attenuation by Roof Cladding Systems - Phase 1 Literature Review and Project Proposal
- Report No. 71, version 1.0 20/9/2010 Noise Attenuation by Roof Cladding Systems, Laboratory Testing Part 1, Results: Cladding Only
- Report No. 72, version 1.1 25/5/2011 Noise Attenuation by Roof Cladding Systems, Laboratory Testing Part 2, Results: Roof systems
- Report No. 73, version 1 19/9/2011 Road Traffic and Aircraft Noise Spectrums