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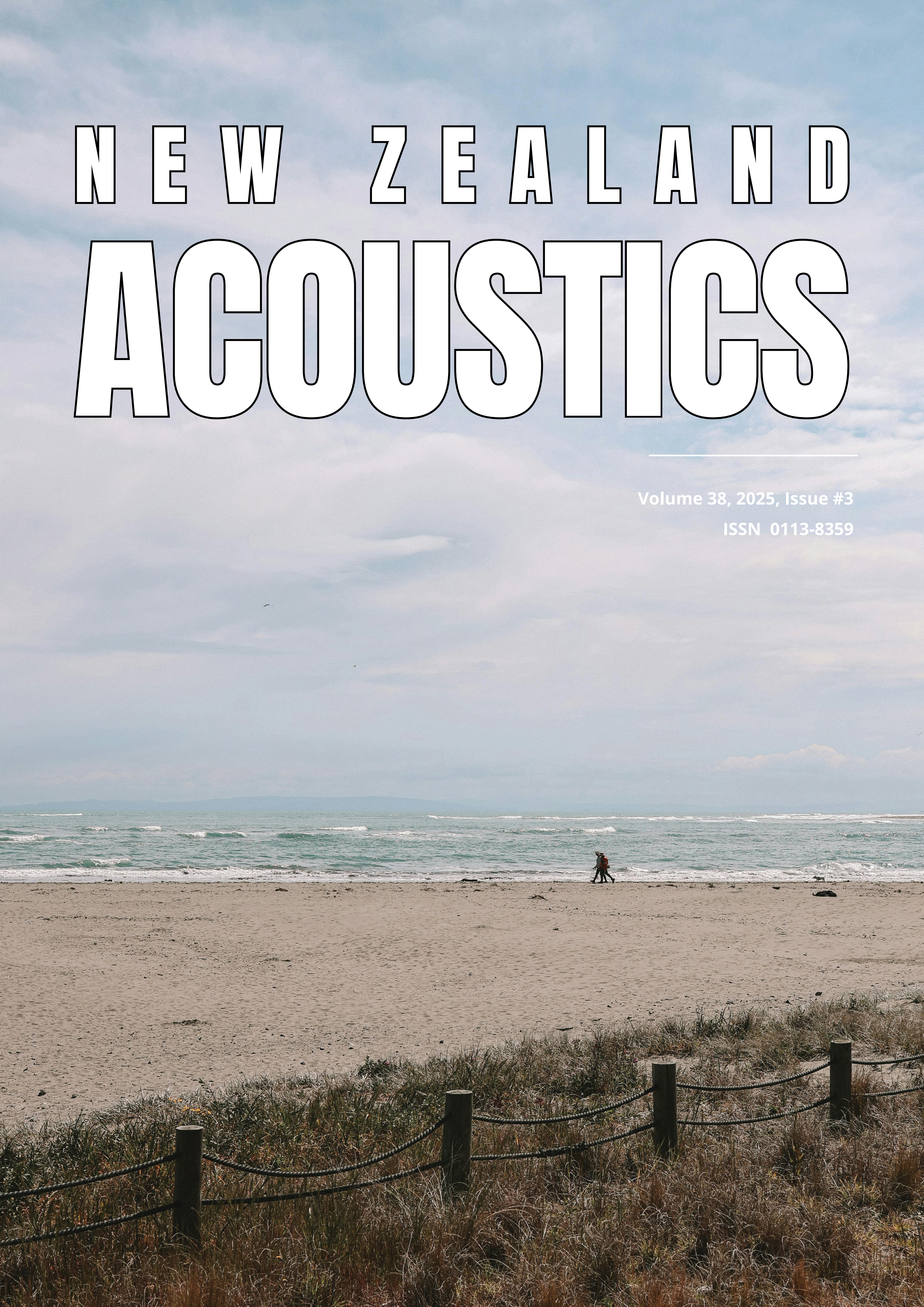

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## Community response to transport noise exposure in New Zealand

*" Environmental noise can harm human health and negatively impact people's daily activities. It can cause a range of disturbance and annoyance reactions among individuals. Building on a socio-acoustic survey that was undertaken in Auckland in 2016, the objectives of this second research study were to define and quantify the responses to noise exposure from road traffic, railways and aircraft in selected locations throughout New Zealand.*

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## Evaluating the application of sound level meters in excessive noise enforcement: Feasibility and constraints

*"The Resource Management Act 1991 (RMA) regulates noise by requiring every occupier of land to adopt the best practicable option (section 16) to avoid generating unreasonable noise. Councils may establish objective noise limits in district plans, typically based on land-use zones, specific areas, or times of day. Under section 326, councils are also required to manage and respond to excessive noise, commonly referred to as the noise control service, which is assessed subjectively by Council Officers without the need for formal sound measurements or recordings."*

***Lindsay Hannah, Wyatt Page and Edward Dyer***

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## Improving surfaces for quieter roads

*"Waka Kotahi has been investigating how to reduce road-traffic noise for over 30 years. For most of this time the focus has been on reducing noise from the tyre/road interaction, which dominates road-traffic noise emission. 10 years ago, NZ's first close-proximity (CPX) noise measurements unexpectedly revealed very high longitudinal variability in the noise emission of porous asphalts on the highway network (± 4 dB)."*

***Richard Jackett, George Bell, John Bull, Stephen Chiles and Rob Wareing***

## Tracy Hilliker

*President of the Acoustical Society of New Zealand Inc.*

Dear Members,

As summer approaches, the days grow longer, and it is a fitting time to pause and reflect. This year has marked a significant chapter for ASNZ – one of transformation, collaboration, and forward-thinking change. Key milestones include updates to our membership structure, establishment of a dispute resolution pathway, and the ratification of our new Constitution. These changes lay the foundation for a more inclusive and resilient future. Thank you to everyone who recently attended the AGM and supported these important changes; your engagement continues to shape our Society's future.

Behind the scenes we have been working diligently on the launch of the new ASNZ website. While the process has taken longer than expected, every extra hour invested reflects our commitment to delivering a platform that truly serves our members. From streamlined navigation, enhanced member access, and dedicated resources including journal archives and dispute resolution information, the site will be a more efficient and user-friendly hub for our community. Thank you for your patience – we're excited to share it with you soon.

Congratulations to Stuart Bradley, our newest ASNZ Fellow! We celebrated Stuart's longstanding contribution to our Society and wider industry at a special event held in September. His dedication and expertise continue to leave a lasting impact on our community, and it was a pleasure to honour his achievements alongside colleagues and friends, a recognition well deserved.

Planning is underway for our next conference in November 2026, located in the beautiful Tauranga; the first time we have chosen to host outside of a major city centre. A vibrant coastal city, Tauranga is known for its temperate climate, natural beauty, urban energy, and cultural richness. I will be joining our Australian friends in Perth shortly for the AAS Conference and am excited to promote what promises to be another successful ASNZ event.

As we wrap up a remarkable year, we are grateful for your continued support, collaboration, and passion for acoustics. I extend a special thanks to our Council and those involved in Standard development – your efforts have been instrumental in our progress. As the festive season nears, keep an eye out for invites to our end-of-year branch celebrations. We would love to see you there and raise a glass to everything we have achieved together.

Looking ahead to 2026, I remain cautiously optimistic that our gradual economic recovery will gain momentum, supported by lower interest rates and easing inflation. However, the economic outlook is still not without challenges and risks, and it is important we continue to take care of ourselves and support one another. I encourage everyone to take time to unwind and recharge over the summer break. Whether you are enjoying quiet reflection, active pursuits or festive gatherings, may this season bring you peace, happiness, and renewal – with just the right resonance to carry you into the new year. I look forward to reconnecting with you again soon, refreshed, and ready for the exciting journey ahead.

Ngā manaakitanga,

**Tracy Hilliker**

President of the Acoustical Society of New Zealand Inc.

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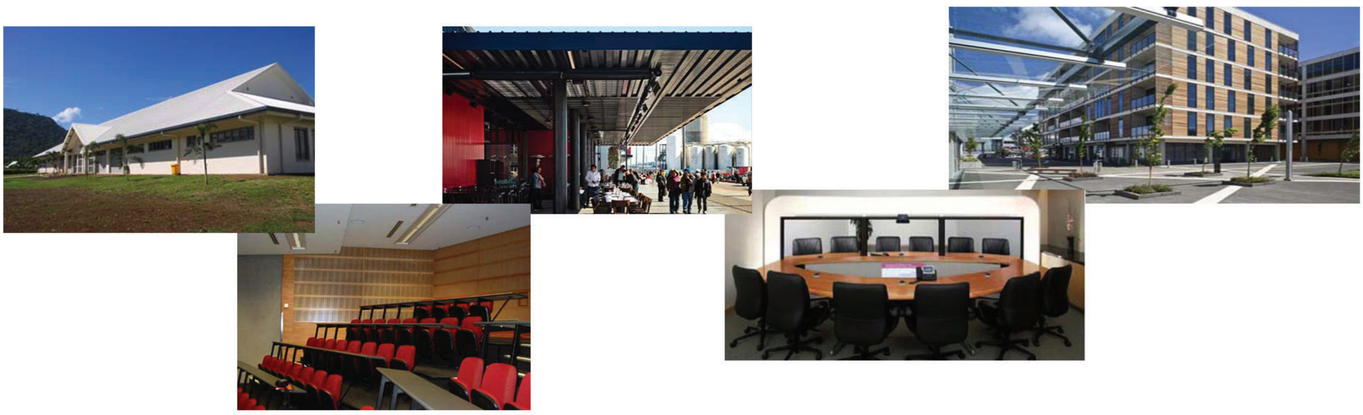

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## Lindsay Hannah and Wyatt Page
*Principal Editors*

Tēnā koutou katoa, Talofa lava, and welcome

Welcome to the final edition of *New Zealand Acoustics* for 2025, our third and closing issue of the year. As the festive season approaches, it's a natural time to pause and reflect. With summer upon us, the longer evenings and warmer days are a welcome change after the chill of winter. It's the perfect opportunity to reconnect with friends and family, enjoy the outdoors, and take time for both physical and mental well-being, even a simple walk can make a difference.

In this edition, we bring you our usual mix of updates, news, and event coverage, along with the now-traditional quiz. We also feature a diverse selection of papers, including several from the 2024 Conference of the Acoustical Society of New Zealand, covering key topics in building, roading, and vibration. Highlights include *Comparing Measured Ground-Borne Noise Levels, Community Response to Transport Noise Exposure, Improving Road Surfaces for Quieter Roads,* and *Evaluating the application of sound level meters in excessive noise enforcement: Feasibility and constraints.* Among others. We encourage readers to explore these insightful contributions.

Our sincere thanks go to everyone who has contributed to the journal and the Acoustical Society of New Zealand throughout 2025, advertisers, authors, peer reviewers, the editorial team, and our engaged readers. Your contributions keep this journal moving and growing.

We continue to welcome submissions from across the acoustics community, whether you are a student, a professional, or working across other disciplines. We love seeing diverse papers and sharing knowledge across our small but vibrant community.

We hope this issue informs, challenges, and inspires your work in acoustics. Enjoy the summer, take care over the holidays, and stay safe.

Wyatt and I look forward to seeing you all back in 2026.

Tofa soifua, Ka kite anō, and Meri Kirihimete

**Lindsay Hannah & Wyatt Page**
Editors-in-Chief

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## The Noise We Know

From dawn's first beep to midnight's glow
The noise of life begins to grow
A constant hum, a buzzing stream
The soundtrack of our wired dream

We chase the call, the endless scroll
A million voices, none quite whole
The city shouts, the sirens scream
Lost in the chaos of the stream

Earbuds drown the world outside
While screens and pixels all collide
Notifications never cease
A restless hum, no chance for peace

Yet in this roar, we find our place
A noisy, crowded, fast-paced race
And still we long for quiet, though
We live within the noise we know

*Shannon Lidyah Series 2025*

# Comparing Measured Groundborne Noise Levels against Vibration-to-noise Prediction Methods

*Cameron Walbran [1] and Lewis Bullivant [1]*

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*c.walbran@ndy.com*

## Abstract

Prediction methods for groundborne noise inside buildings from floor vibration levels in concrete buildings have been proposed by several researchers including Nelson (providing an upper bound and a lower bound) and the United States of America Federal Transit Authority. These prediction methods have considerable spread in the corrections applied to the measured vibration level; as such it can be difficult to prescribe treatment measures with confidence. The research presented in this paper aims to assess each of the prediction methods against measured noise levels in an existing building located over a railway using simultaneous vibration measurements. With neither the building nor the rail tracks having in-built isolation, this presented a prime opportunity to establish which, if any, of the groundborne noise prediction models matched the measured noise levels. The analysis has found that for this particular building, measured groundborne noise levels most closely matched the Nelson – Halfway prediction, though some spread exists in the measured data.

## Introduction

This paper compares groundborne noise prediction methods that use floor vibration measurements as the input, against measured noise levels resulting from rail movements in a concrete building.

## Background

The global trend of increasing population density in urban settings is resulting in sensitive building uses being located near noise- and vibration-producing activities, in particular rail corridors. This proximity can result in noise and vibration from rail movements transmitting into building foundations via the ground (or tunnel structure in the case of underground lines). While new railway tracks in urban areas often incorporate an isolating medium to reduce the effects of noise and vibration on surrounding properties, some older rail lines are installed on grade or concrete with no isolation, allowing greater noise and vibration to transmit into nearby buildings.

Assessment of noise and vibration becomes an important consideration in the preliminary design and planning of new developments located near these unisolated railway lines. The assessment methodology for concrete structures typically involves placing vibration sensors at locations pertaining to the building foundations and measuring velocity levels from train pass-bys. After a sufficient number of train pass-bys are captured, correction factors are applied to account for soil-to-foundation coupling losses, floor-to-floor losses, and floor slab amplification. The resulting floor vibration can then be converted into a predicted sound pressure level to obtain an estimate of the groundborne noise resulting from rail movements.

Several vibration-to-groundborne noise conversion factors have been proposed over the years, by Nelson [1], and the USA Federal Transit Authority [2]. An in-house conversion factor has also been used on projects over the years. These studies provide absolute adjustments to the measured 1/3-octave band vibration level (Figure 1) based on field studies carried out in Australia and North America over twenty years ago. This study aims to compare these prediction methods to a field survey carried out recently in Auckland to obtain updated estimates for groundborne noise conversion applicable to typical New Zealand building typologies.

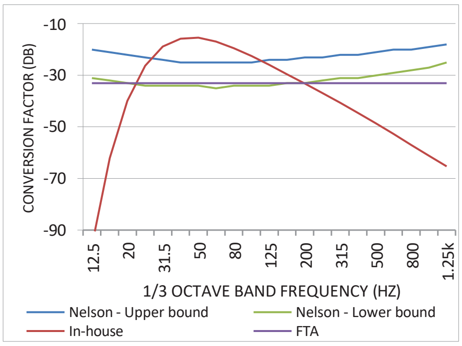


Figure 1: Conversion factor from velocity level (dB re 1 nm/s)

## Test Methodology

Floor vibration measurements were recorded in several locations (Figure 2) across the floor plate of an existing concrete building situated directly above a rail tunnel. Vibration from train pass-bys was measured using a triaxial accelerometer and vibration analyser with the measurement duration capturing the entire train pass-by, ranging from 20 s to 60 s in length. The maximum RMS vibration velocity was recorded using a 1s averaging time.

For each vibration measurement in each position, a sound level meter measured the $L_{Asmax}$ noise level for each corresponding train pass-by. This resulted in simultaneous floor vibration and noise level measurements being recorded for each pass-by. The measured floor vibration was then converted to sound pressure level using the aforementioned conversion factors and were compared directly to the measured sound pressure levels. Five train movements were captured in each location.

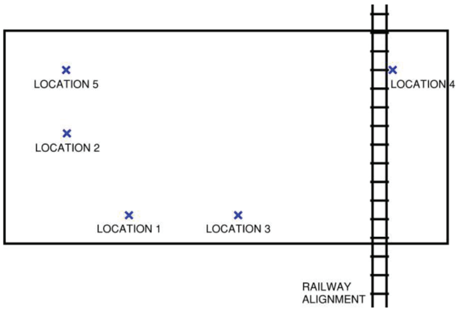


Figure 2: Measurement locations

### Building Typology

The building has a full concrete structure with concrete foundations, slabs, columns and beams. Floor spans range from 7.45 m to 9.55 m. The building was fitted out with the majority of the floor plate being open plan with a central core. Measurements were carried out at Level 1 of the building on a suspended slab; locations were chosen to reflect the potential worst case vibration levels, i.e. the centre of the structural bay.

## Results and Discussion

Figure 3 presents the predicted sound pressure levels for all measurements using the Nelson and in-house conversion factors along with the corresponding measured sound pressure level. Every fifth measurement represents a new measurement location, i.e. measurement numbers 1-5 are location 1, 6-10 are location 2, etc.

An additional conversion factor has been added to the results chart, representing the halfway point between the upper and lower bounds of the Nelson conversion factor.

For the majority of measurements, the measured sound pressure level falls between the Nelson – Lower Bound & FTA and Nelson – Halfway predictions. Both the in-house method and Nelson – Upper Bound tend to overpredict groundborne noise and Nelson – Lower Bound and FTA tends to underpredict groundborne noise. One notable exception is location 4 (i.e. measurements 16-20) where the measured noise level falls 2-7 dB below the Nelson – Lower Bound and FTA predictions.

The measurements indicate that when converting from floor vibration to groundborne noise levels in a typical office building, the Nelson – Halfway conversion factor provides a reasonable estimation. Given there remains some spread in the measured noise level compared with the prediction methods, particularly location 1, it would remain prudent to apply a typical safety factor onto groundborne noise predictions of up to 2 dB.

## Limitations and Next Steps

Several limitations are present in this study and are addressed below.

### Aorborne Noise Ingress

Some airborne noise was present in the noise measurements, particularly locations 1 and 3, due to the location of the building being adjacent to the railway. This may have resulted in some measured noise levels overrepresenting the amount of groundborne noise present. Given this would result in a more conservative conversion factor rather than a more lenient conversion factor, this is not considered a major concern for the purpose of this study. To further improve this study the effects of airborne noise contribution should be studied to determine the level of influence that airborne noise ingress had on the overall measured noise levels.

### Room Effects

The study does not consider the effects of sound absorption. Nelson [1] provides a formula to estimate groundborne noise based on the measured floor vibration velocity level and the absorption coefficient:

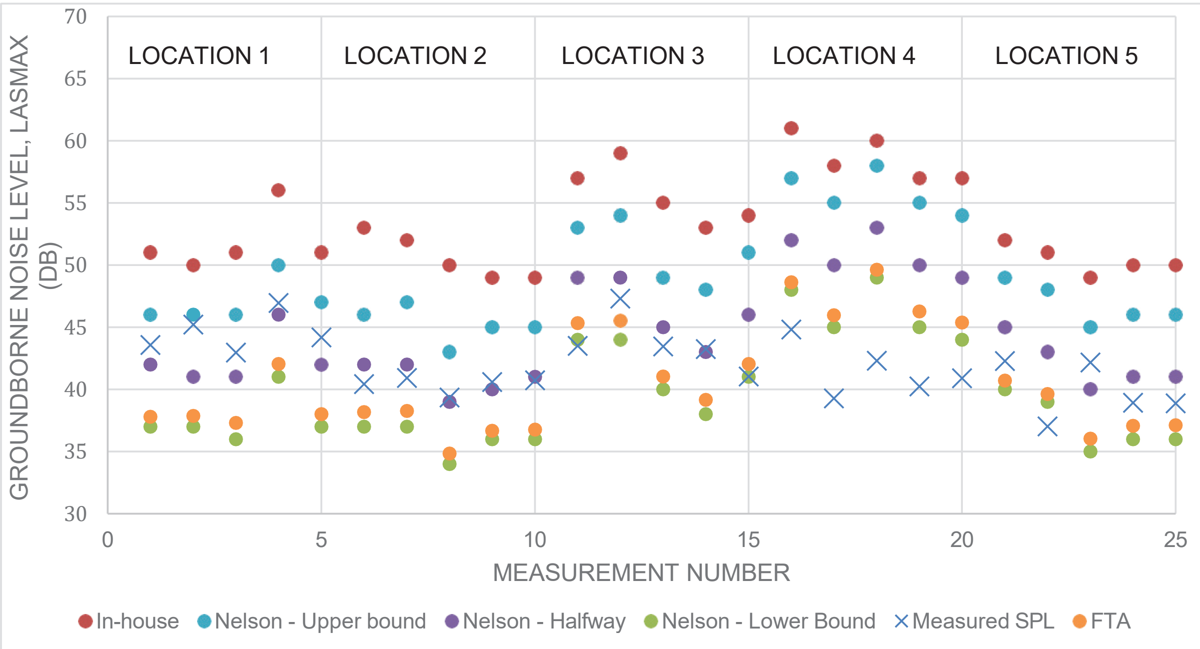


Figure 3: Predicted sound pressure levels vs, measured

$$SPL = L_v - 10\log(a) - 1 \quad (1)$$

Where $SPL$ = sound pressure level (dB re 20 μPa), $L_v$ = vibration velocity level (dB re 1 μin/s), and $a$ = absorption coefficient.

This could be incorporated into the study by creating spatial acoustic models of the floor plate and using the resulting room absorption to estimate groundborne noise levels.

### Spectral Comparison

The study compares the predicted overall noise level against the measured overall noise level. A comparison of the noise spectrum may yield a would provide insight into whether the conversion factors produce close estimates across the frequency spectrum and may yield a conversion factor with greater spectral detail.

## Conclusion

This paper compares predicted groundborne noise levels converted from floor vibration measurements against measured noise levels. Simultaneous floor vibration and noise measurements of train pass-bys have been carried out in a typical concrete building in Auckland located over a rail tunnel.

The floor vibrations have been converted to estimated groundborne noise levels based on several published conversion factors. These estimated groundborne noise levels have been compared against the actual measured noise levels carried out simultaneously to determine which conversion factor fits best.

Through the measured locations it was apparent that the Nelson – Halfway conversion factor provided the best fit. As such, for a typical concrete office building in New Zealand, this paper suggests that the Nelson Halfway conversion factor is the most appropriate method to convert from floor vibration velocity levels to groundborne noise levels.

## References


[1] J. T. Nelson and H. J. Saurenman "A Prediction Procedure for Rail Transportation Groundborne Noise and Vibration" *Transportation Research Record 1143*

[2] A. Quagliata, "Transit Noise and Vibration Impact Assessment Manual", FTA, U.S. Dept. of Transportation, 2018



The next Acoustical Society of New Zealand biennial conference is locked and loaded... and is going to be in Tauranga Moana!

The theme is "... And now for something completely different!", which admittedly isn't a very typical theme for a conference. It has been chosen for two excellent reasons:

1) Tauranga – a beautiful harbour city in the Bay of Plenty – will be the first city outside of Auckland, Wellington and Christchurch to host our conference. It is 2.5hrs drive (or a quick 45min flight) from Auckland on the Aotearoa east coast. Famed for its white sand surf beaches at Mount Maunganui and Papamoa, and for 'The Mount' itself... an iconic volcanic standing tall above the waves (named Mauao in Te Reo Māori)

2) The world is a very serious place right now. Geopolitical tensions are high around the globe, and some once reliable government institutions appear to be fixated on fighting fire with petrol. Parody and irreverence have long been used as coping mechanisms for the masses, so our 2026 Conference is going to provide us with something to chuckle about by being just a little bit… silly

We will still have a delectable array of high-quality papers and presentations. Our keynotes (to be announced) will still be expertly selected for their knowledge on the current hot topics from at home and abroad. We will promote the same friendly, collegial atmosphere in which to meet, reacquaint and share a laugh with like-minded individuals. We will provide a splendid array of trade stands thanks to the unwavering support of our sponsors. All the key ASNZ conference ingredients will still be present, but in an entirely new city… and possibly involving silly hats.

Hope to welcome you to Tauranga in November 2025!

James Whitlock – Conference Chair

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# Community response to transport noise exposure in New Zealand

*Darran Humpheson [(1)] and Katrina Magill [(2)]*

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## Abstract

Environmental noise can harm human health and negatively impact people's daily activities. It can cause a range of disturbance and annoyance reactions among individuals. Building on a socio-acoustic survey that was undertaken in Auckland in 2016, the objectives of this second research study were to define and quantify the responses to noise exposure from road traffic, railways and aircraft in selected locations throughout New Zealand.

A total sample of 2,212 respondents completed the survey. The findings of the study can be extrapolated to the New Zealand population exposed to transport noise on the basis that the wider exposed population have on average the same opinions as the sample population. When compared to the World Health Organization 2018 environmental noise guidelines, the sampled New Zealand population is more sensitive to road-traffic noise, is less sensitive to railway noise and has similar sensitivities to aircraft noise. The study's findings for road- traffic and railway noise are comparable to the findings of the 2016 New Zealand study.

## Introduction

Environmental noise can harm human health and negatively impact people's daily activities at home, school, work and during leisure. The World Health Organization'S (WHO) 2018 environmental noise guidelines [1] recommend maximum admissible noise levels to protect population health. Long-term annoyance, impaired wellbeing and self-reported sleep disturbance due to noise are classified by the WHO as health outcomes. Annoyance response is the most readily measurable and reliable indicator in self-reported socio- acoustic surveys.

Environmental noise caused by transportation can cause a range of disturbance and annoyance reactions among individuals. The threshold at which individuals will be annoyed by these sources of noise will vary depending on their expectations and sensitivity to noise. When combined at a population level, exposure response functions (ERFs) derived from the percentage of people reporting being highly annoyed for a given noise exposure level can be generated for different forms of transport. These exposure response relationships can be compared to similar research. Differences between studies may exist due to non-acoustic factors that influence reported annoyance.

## Previous Work

In 2016, the New Zealand Transport Agency (NZTA) commissioned a socio-acoustic survey [2] to determine exposure response relationships based on a comparison of short-term changes in noise compared to existing steady- state (long-term) conditions. The 2016 study surveyed respondents living in Auckland who were exposed to road-traffic noise and railway noise. The road-traffic sample included n=557 responses along State Highway 1 and near the Waterview Tunnel and the railway sample included n=244 responses along the main passenger line.

Due to a number of limitations, the short-term change assessment could not be fulfilled. However the steady- state analysis did show that the percentage of people highly annoyed for a given noise exposure was comparable with similar international studies, although in each case, the onset of annoyance occurred at marginally lower noise exposure levels.

Out of a list of 10 sources of environmental noise, the 2016 study found that road-traffic noise was rated highest, and for the railway study area, trains were rated the fifth most annoying noise source.

Respondents were asked to provide general feedback on noise and other matters. It was noted that lifestyle impacts were a concern, which included general disturbance and interference with their quality of life. Interestingly, driver behaviour accounted for the greatest number of comments, with 'boy racers' and trucks being cited as the two most common sources of noisy events.

To further assist with understanding New Zealanders' response to transportation noise, a second socio-acoustic study was undertaken to assess short-term and long-term response to transport noise exposure. This second study was again commissioned by the NZTA and was undertaken between 2021 and 2024.

## Study Overview

Unlike the previous study and to align with the bulk of international transportation noise research, aircraft were included as a mode of transport. The scope of the study was also extended to include roads and railways outside of Auckland (covering the North and South Islands).

The study commenced in 2021 and coincided with COVID-19 restrictions and the subsequent reduction in transportation activity within New Zealand. Socio- acoustic surveys were delayed until activity levels had returned to near normal levels, and were conducted between September 2022 and January 2023. Due to the intervening period, it was not appropriate to assess short-term response to transportation noise.

**Noise exposure levels**

Noise exposure data at a respondent level is needed to derive ERFs for road-traffic, railway and aircraft noise. A combined road-traffic and railway noise model was developed by AECOM as part of the NZTA *Social cost (health) of land transport noise exposure in New Zealand* research study [currently unpublished]. The outputs of the AECOM model were used to derive noise exposure levels at an address level of detail (i.e. at individual dwellings). Aircraft noise exposure levels were derived from published aircraft noise contours using geospatial analysis also at an address level of detail. Road-traffic and railway noise exposure levels were based on 2021 input data. Aircraft noise exposure levels were based on 2019 noise contour data.

**Road-traffic model**

Road alignments, terrain and building details were imported into the road-traffic and railway model developed by AECOM. The road-traffic model included:

- highways
- regional roads
- arterial roads
- buildings and land parcels within 300 metres of road alignments
- terrain data within 300 metres of road alignments.

Road alignments included data on the posted speed limit, road surface condition, annual average daily traffic numbers and percentage of heavy vehicles comprising the total traffic.

Road-traffic noise exposure levels were calculated using the calculation of road-traffic noise methodology [3], which presents a result in terms of $L_{10,18h}$. This was adjusted to $L_{Aeq(24h)}$ by subtracting 3 dB in accordance with the Noise Advisory Council [4]. $L_{den}$ was then calculated using established conversions [5].

The model accuracy relied upon the validity of the calculation of road-traffic noise, and noise monitoring to validate the results was not undertaken. The model only predicts the average noise exposure level at residential dwellings and therefore discrete events such as truck engine braking, loud exhausts or audio tactile road markings (rumble strips) are not included in the model. Any roads without a complete dataset of information were removed from the study.

**Railway model**

Railway alignments were obtained from the KiwiRail Network Map. The AECOM railway model included:

- main truck lines
- secondary main lines
- branch lines
- buildings and land parcels within 300 metres of rail alignments
- terrain data within 300 metres of rail alignments.

Each trunk line included a posted speed limit, which was assumed to be the operational speed of trains. Noise levels were calculated using the calculation of rail noise methodology [6], which predicts noise at the wheel-level based on the speed, length of the train, type of track and track support system. Individual train source noise levels specific to New Zealand were gathered from measurements undertaken by AECOM.

Aspects not included in the model include:

- noise from track sidings, rail stabling yards or other types of supporting or maintenance infrastructure
- acceleration and deceleration around train stations
- any possible variation in speed to account for track conditions or rail gradients
- any variation in noise from maintenance-based influences such as variability in rail head roughness
- noise from the use of klaxon horns or other safety devices such as warning bells or PA systems
- private rail networks
- rail corridors without rail volume data.

**Aircraft noise contours**

Airport companies may publish annual aircraft noise contours as required by a condition of consent, designation or part of their monitoring or noise management plan requirements. These contours show areas exposed to noise using the $L_{dn}$ metric as required by NZS 6805:1992 [7]. Generally, aircraft noise contours are produced from 55 to 65 dB $L_{dn}$, and these contours tend to be modelled on the busiest 3 months of the year. Noise levels at individual dwellings can be interpolated and extrapolated from these contours. Geospatial tools were developed to undertake this analysis, including the use of published flight tracks to extrapolate the contours down to 45 dB $L_{dn}$.

The study was reliant on the availability of the published contours and no quality assurance steps were undertaken to validate the contours. As with other forms of noise modelling, aircraft noise contours are subject to some degree of uncertainty. A 2 dB variation is typical between modelled and actual noise levels.

## Study Area Selection

The study objective required surveying people exposed to each of the three transportation sources of interest – road- traffic, railway and aircraft noise. Quantifying community response to new and altered roads requires socio-acoustic surveys being completed within 12–18 months of the opening of the road; prior to likely habituation or acceptance of the noise environment. Unlike the roading network, no significant changes to the rail network or changes to airports have occurred since 2019. Therefore, the short-term assessment was limited to suitable roading projects.

Due to the effects of the COVID-19 pandemic, the socio-acoustic surveys were completed in 2022, which meant that the intervening period between study areas being selected (and the noise exposure levels being modelled) and conducting the surveys was more than 18 months. The intervening time meant that the newer roads were considered established enough that the annoyance response would have normalised. Therefore, for the purposes of this research study, it was agreed that only steady-state conditions would be investigated. Those study areas originally selected for the short-term assessment were included in the full assessment.

The main selection criteria were:

- dwellings exposed to more than 40 dB $L_{Aeq(24h)}$ from road-traffic or railway noise
- dwellings exposed to more than 45 dB $L_{dn}$ from aircraft noise

Road-traffic study areas were selected for a representative cross-section of road types, road surfaces and traffic volumes and for recent new or modified roads. Railway study areas comprised national freight and passenger routes, with freight services being predominantly in the South Island. Airports were identified where aircraft either fly over or near residential areas and there is a sufficient range in noise exposure. Auckland, Tauranga, Rotorua, Wellington and Queenstown Airports were initially selected. Christchurch Airport was not considered in the study despite its size due to the low number of people within the 55 dB $L_{dn}$ contour. Tauranga Airport was not considered suitable due to the small sample size and limited range in noise exposure levels. Wellington Airport was also not considered suitable due to a scheduled hearing that would have occurred during the surveying period and the perceived risk that increased engagement/media attention may bias reported annoyance. The selected airports were Auckland, Rotorua and Queenstown Airports.

Due to the COVID-19 pandemic, aircraft noise levels at individual dwellings were based on contours published for the year 2019. These contours reflect a greater level of aircraft activity than took place when the social surveys were being conducted. For example, at Auckland Airport, movement numbers in 2022 were at approximately 70% of 2019 movement numbers, whereas for Queenstown Airport, movement numbers were at 87% of pre-COVID- 19 levels. Assuming that the mix of aircraft types remain the same between the two intervening periods, Auckland would have experienced a $L_{dn}$ reduction of 1.6 dB and Queenstown a 0.6 dB reduction. Variations in movement numbers between the two periods (2019 and 2022) were included in the uncertainty analysis, as explained later in this paper.

Population centres around busy sections of railway are often close to arterial road transport routes. To identify sufficient study areas near railways, judgement was used to identify which nearby roads would not influence the community opinion of the railway noise – areas where the railway noise is more dominant. A similar approach was used for the airports, such that locations were selected away from areas of dominant road-traffic noise (railway noise was not considered as two of the airports were unaffected by rail). ERFs are known to be influenced by factors other than noise exposure level. Some of these factors can vary based off variables that are specific to an area such as local circumstances and perception of the mode of transport among the community. As recommended by Humpheson and Wareing [2], multiple study areas across the country were surveyed to increase the response rate and to minimise any uncertainties arising from these non-acoustic factors.

## Survey Design

Households invited to participate in this research were selected within individual census meshblocks from the pre-identified areas. This enabled the capture of a representative spread of noise exposure bands.

Noise exposure data at an address level of detail was provided to Research New Zealand and cross-referenced to electoral roll records using postal address information to ensure that the details were current and to obtain more detailed information for recruitment purposes, including contact names and flat/apartment numbers. As no telephone numbers are available via the electoral rolls, the sample was also sent to a third-party provider for tele- matching. The tele-match rate was 7% (approximately 15,000 out of a total sample of 205,250 individuals). Tele- matching rates in general have been declining over time as more people are removing their landlines and using mobile phones or no longer listing their contact details in public directories. The tele-matching company that provides public contact details has access to some mobile phone lists but these are not as extensive as the landline listings used to be.

The research team concluded the tele-matched sample was the most appropriate sample pool to use for this study due to the benefit of being able to easily contact these people by telephone. However, it was recognised that there was a trade-off against the wider representative population that could have been achieved by random sampling from the entire pool of 205,250 individuals. The demographics of those who could be tele-matched compared to those not tele-matched are likely to have differed. This trade-off was addressed in the survey by the use of data weighting. One further benefit of using the tele-matched electoral roll records is that it ensured that all respondents had lived within the study areas for at least an established period of time (typically greater than 12 months), thereby removing the need to enquire whether respondents had lived at their address for less than 12 months.

The survey questionnaire was based on that used by Humpheson and Wareing [2] with standardised noise annoyance questions based on ISO/TS 15666:2021 [8]. Additional questions included time-of-day factors, health and general wellbeing questions, interventions used to reduce annoyance and respondents' views of the noise source and those responsible for the relevant transportation infrastructure. The questionnaire was designed in collaboration with NZTA, steering group members and a peer reviewer. The questionnaire was cognitively pre-tested and piloted in September 2022 prior to the survey proper being launched in October 2022, with completion in early January 2023

All invited respondents were initially sent a paper version of the questionnaire in the mail. Respondents were informed that they could complete the survey by returning the paper questionnaire or completing it online or they could do the survey by telephone either when contacted by one of Research New Zealand's interviewers or by contacting Research New Zealand directly by telephone. The average interview length when the surveys were completed by telephone was 20 minutes.

To achieve the intended target response of n=2,000 survey completions, 13,854 respondents were invited to take part, see Table 1 for a breakdown.

Table 1: Number of surveys for each mode

| | Total | Road | Railway | Aircraft |
|---|---|---|---|---|
| Invited | 13,854 | 4,483 | 6,038 | 3,333 |
| Online | 383 | 155 | 118 | 110 |
| Paper | 1,344 | 295 | 655 | 394 |
| Telephone | 485 | 358 | 2 | 125 |
| Total | 2,212 | 808 | 775 | 629 |
| Participation rate | 16% | 14% | 13% | 23% |

## Findings

Table 2 presents a demographic profile of the total sample of respondents. To ensure the data could be analysed on a representative population basis, the data was weighted by age and gender and used as the basis for all the analyses of the survey's results.

Table 2. Demographic profile or respondents

| | Unweighted n=2,212 | Weighted n=2,212 |
|---|---|---|
| Age | | |
| 18–24 | 1 | 6 |
| 25–34 | 6 | 24 |
| 35–44 | 9 | 16 |
| 45–54 | 12 | 17 |
| 55–64 | 20 | 16 |
| 65–74 | 26 | 12 |
| 75+ | 25 | 8 |
| Male | 38 | 48 |
| Female | 61 | 51 |

Note: Totals may not add to 100% exactly due to rounding.

All survey respondents (the total sample irrespective of study area) were asked to rate the extent to which they were bothered, disturbed or annoyed by nine sources of environmental noise using the 11-point ISO/TS 15666:2021 [8] annoyance question where 0 = not at all annoyed and 10 = extremely annoyed. A score of 8 or more being classified as highly annoyed (HA). Table 3 shows 20% of all respondents were highly annoyed by road-traffic noise. This result is at least twice as high as any other noise source. The next most commonly identified source of high annoyance was aircraft noise identified by 10% of all respondents. Relatively few respondents (4%) reported being highly annoyed by railway noise.

Table 3. Demographic profile or respondents

| Rank | Source | Total sample n=2,212 %Highly Annoyed |
|---|---|---|
| 1 | Road-traffic | 20 |
| 2 | Aircraft | 10 |
| 3 | Animals outside | 9 |
| 4 | Construction works | 8 |
| 5 | Other people outside | 8 |
| 6 | Factories or machinery | 6 |
| 7 | Trains | 4 |
| 8 | Children outside | 3 |
| 9 | Pubs and night clubs | 1 |

Respondents who reported being annoyed or bothered by noise at home were asked if they believed it had got worse, better or stayed the same in the last 12 months. Responses were analysed on the basis of those respondents who rated a 3 or more on the 0–10 annoyance scale (more than slightly annoyed). Based on further analysis, this was deemed to be the most appropriate basis even though it departs from the sections of the scale used for other analyses. Relatively few noted any change for the better:

- 57% of road-traffic sample respondents who were more than slightly annoyed by road-traffic noise felt it had not changed in the past year, 38% thought it had got worse and 2% thought it had got better.
- 74% of railway sample respondents who were more than slightly annoyed by railway noise felt it had not changed in the past year, 18% thought it had got worse and 5% thought it had got better.
- 52% of aircraft sample respondents who were more than slightly annoyed by aircraft noise felt it had not changed in the past year, 33% thought it had got worse and 11% thought it had got better.

It is uncertain whether these reported changes are due to the recovery effects after the COVID-19 pandemic – which was more noticeable in the aviation sector due to the slower recovery in the international sector.

All respondents were asked to rate how sensitive in general they were to noise using a scale of 0–10 where 0 = not at all sensitive and 10 = extremely sensitive. Most respondents did not consider themselves to be overly sensitive to noise in general, with 49% rating their sensitivity as 0–4 on the 11-point scale. In comparison, 14% rated themselves as an 8–10, indicating high sensitivity. Of the three samples, the aircraft sample respondents were the most likely to rate themselves as being highly sensitive to noise (20%), followed by 13% of the road-traffic respondents and 10% of the railway respondents.

Respondents were asked to rate their annoyance when at home inside with windows open/closed and when outside. Responses for each survey are shown in Figures 1 to 3.

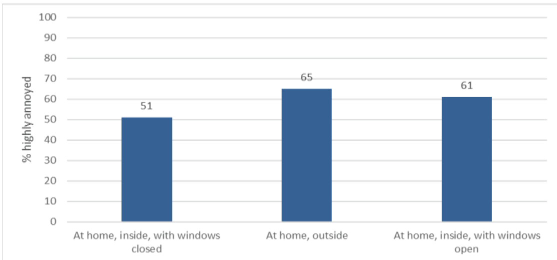


Figure 1. Road-traffic noise annoyance levels when inside and outside of the home

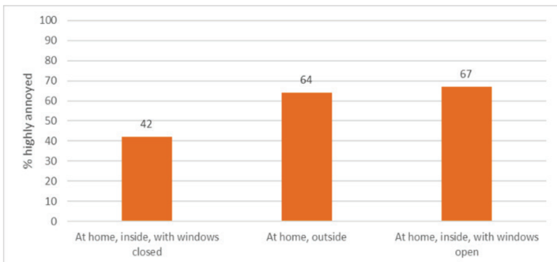


Figure 2. Railway noise annoyance levels when inside and outside of the home

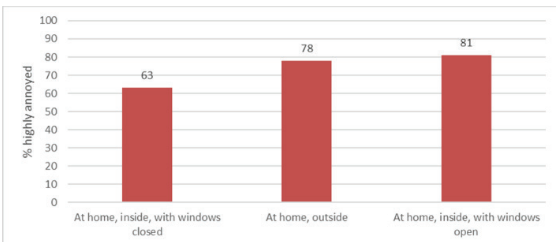


Figure 3. Aircraft noise annoyance levels when inside and outside of the home

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Respondents who reported being bothered by road-traffic noise during the week were asked if there were any particular times the noise was particularly annoying. While 13% said the noise was annoying all the time, evenings and late at night were the most annoying (7pm– 3am). The most annoying times were the same for those who were bothered by road-traffic noise in the weekends.

Almost one-third of the railway sample respondents (30%) reported that railway noise was annoying during both weekdays and weekends. This was particularly the case for those who reported being highly annoyed by railway noise (65% of whom found the noise annoying every day). A further 21% found it most annoying during weekdays, while 15% found the noise to be most annoying in the weekends.

Most of the aircraft sample who were annoyed by aircraft noise (59%) reported that aircraft noise was annoying during both weekdays and weekends. This was particularly the case for those who reported being highly annoyed by aircraft noise (74% of whom found the noise annoying every day), 19% found the noise to be most annoying during weekdays while 9% found it most annoying in the weekends.

Road-traffic sample respondents who reported being annoyed about road-traffic noise while at home were asked to identify what it is about the road-traffic noise that bothers them. The results are summarised in Table 4. The data includes the full road sample in the first data column and the highly annoyed (HA) group in the second data column.

Table 4. Features of road-traffic noise that bother road-traffic sample respondents

| | Annoyed % n=636 | HA % n=148 |
|---|---|---|
| Vehicles with noisy engines, exhausts or horns (including boy racers) | 75 | 77 |
| Particular types of vehicles (cars, trucks, motorbikes) | 43 | 52 |
| Vehicles at night (after 10pm) | 42 | 59 |
| Vehicles in the early morning (before 6am) | 30 | 41 |
| The number of vehicles | 25 | 48 |
| The way the noise makes the house vibrate | 23 | 36 |
| Noise caused by the road (road surface, potholes, manhole covers, rumble strip) | 18 | 23 |
| Something else | 11 | 19 |
| Don't know/no response | 3 | 0 |

Likewise, the railway sample respondents were also asked a similar question, see Table 5.

Table 5. Features of railway noise that bother railway sample respondents

| | Annoyed % n=394 | HA % n=44 |
|---|---|---|
| Trains at night (after 10pm) | 33 | 64 |
| Particular noises that trains make (engines, carriages, squealing wheels, train horns) | 31 | 63 |
| Trains in the early morning (before 6am) | 27 | 59 |
| The way the noise makes the house vibrate | 24 | 59 |
| Particular types of trains (electric, diesel or freight trains) | 21 | 61 |
| The number of trains | 6 | 38 |
| Something else | 15 | 13 |
| Don't know/no response | 22 | 3 |

Table 6 summaries the question posed to the aircraft sample respondents.

Table 6. Features of aircraft noise that bother aircraft sample respondents

| | Annoyed % n=492 | HA % n=140 |
|---|---|---|
| When they fly directly over your house | 53 | 71 |
| Flights late at night (after 10pm) | 37 | 53 |
| Particular types of planes or aircraft | 36 | 41 |
| How low they fly over your house | 34 | 51 |
| Early morning flights (before 6am) | 29 | 54 |
| The number of flights | 24 | 48 |
| During take off | 12 | 7 |
| When on the ground (taxiing, engines running) | 4 | 6 |
| Something else | 4 | 9 |
| Don't know/no response | 7 | 1 |

Respondents for each sample group were asked questions about the layout of their house, whether it was double glazed, whether the house had been acoustically treated for the source of noise and whether mechanical ventilation was installed. Similar responses were recorded for each sample group except that houses in the aircraft sample group were more likely to have mechanical ventilation fitted – 31% compared to 19% in the road-traffic sample and 16% in the railway sample.

Respondents were asked how the noise affected their day to day activities, such as their ability to sleep, listen to music/TV, relaxing outdoors and working or studying at home. The road-traffic and aircraft sample groups reported being most affected by the noise when outdoors, whereas the railway sample groups reported being most affected by how much sleep they get, implying that trains at night is the main source of disturbance for this group. Overall the aircraft sample group reported being more affected than the other two groups across a range of activities.

Each sample group was asked to rate the extent to which the source of noise had affected factors relating to their health and wellbeing using an 11-point scale where 0 = not at all and 10 = extremely. Approximately one-quarter of the highly annoyed road-traffic sample reported that the noise affected how easily they get irritated (26%), how stressful or anxious they feel (25%) and their energy levels (23%). A further 16% said road-traffic noise affected their health and wellbeing in general while 9% said their personal relationships with others at home were affected.

More than one-quarter (28%) of those highly annoyed with railway noise reported the noise had affected how stressful or anxious they feel. Another 25% said it affected how easily irritated they get, while 19% said the noise affected their energy levels and 18% their health and wellbeing in general (35%). 15% of those highly annoyed said the noise had affected their personal relationships with others at home.

Approximately one-third of the aircraft sample said it affected how stressful or anxious they feel (35%), their energy levels (32%) and their health and wellbeing in general (35%). More than one-quarter (27%) of the highly annoyed said the noise had affected their personal relationships with others at home. On a total sample basis, approximately one in 10 of the aircraft sample reported that their health and wellbeing had been affected in some way by aircraft noise (higher than the other two modes).

Each sample was asked what interventions they were planning or undertaking to minimise noise annoyance. A list of nine interventions[1] were provided and the top five results for each sample are presented in Figures 4 to 6.

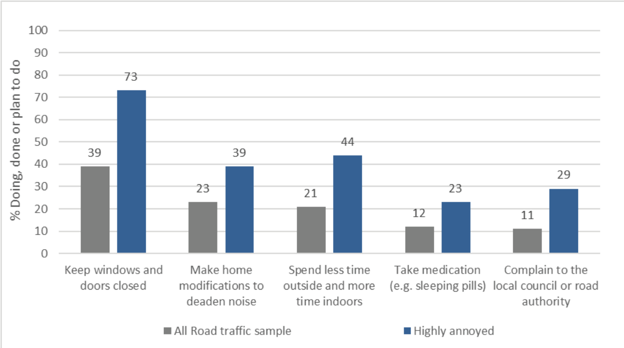


Figure 4. Interventions – road-traffic sample

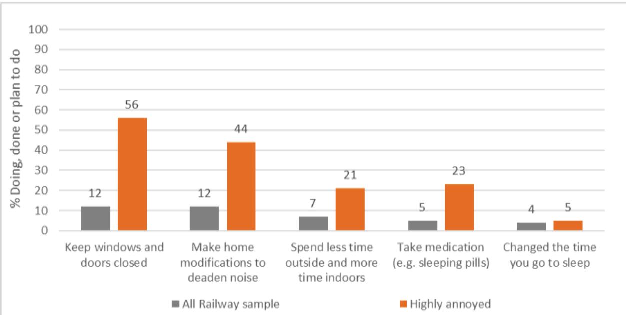


Figure 5. Interventions – railway sample

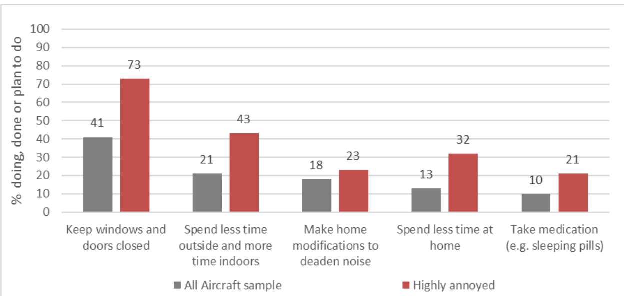


Figure 6. Interventions – aircraft sample

## Response to noise

ERFs have been developed using the relevant noise exposure data and annoyance response of those respondents reporting being highly annoyed. The %HA against noise exposure level for each sample has been generated. For comparison with the WHO guidelines [1], the $L_{den}$ metric has been used.

The derived ERFs (labelled 2022 Survey) have been compared to the WHO 2018 guidelines [1] and the 2016 Study by Humpheson and Wareing [2] (labelled RR656). Prior to 2018, the standardised ERFs were determined by a meta-analysis of socio-acoustic studies by Miedema and Oudshoorn (2001) [9]. Figures 7 to 9 show the ERF curves for each study.

The bounds of the 2022 Survey curves relate to the range of noise exposure levels – extrapolated data is shown as dashed data. Second-order polynomial regression lines were used to derive the ERFs as these regressions result in the best fit across each transport mode.

[1] keep windows closed, insulate home, less time outside, take medication, complain, less time at home, move away, change time going to bed (sleeping), move bedroom

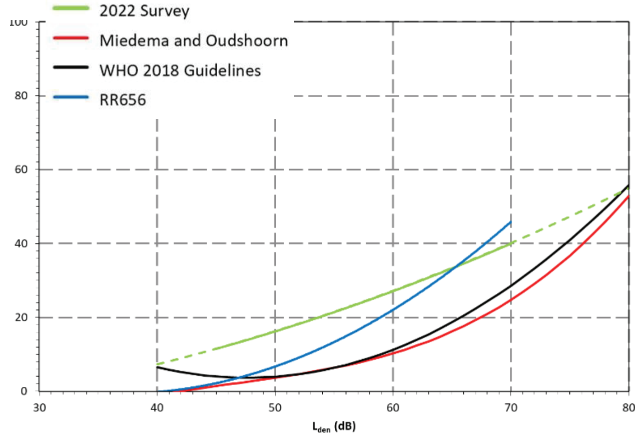


Figure 7. Road-traffic ERF comparison

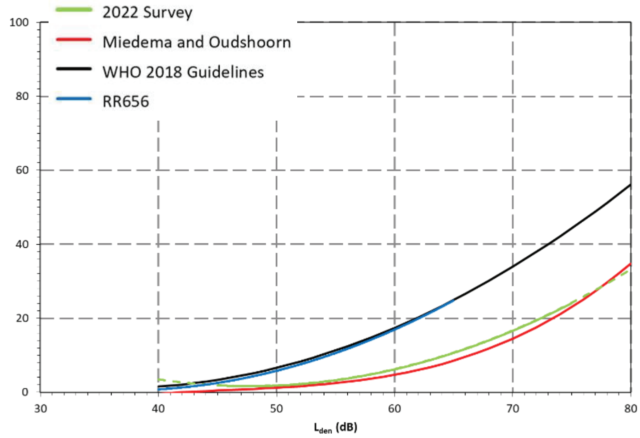


Figure 8. Railway ERF comparison

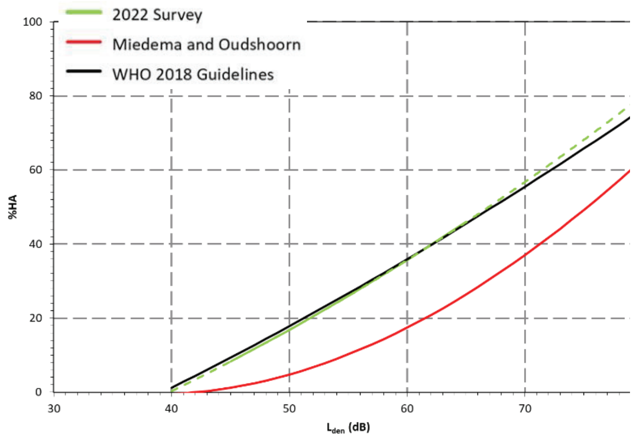


Figure 9. Aircraft ERF comparison

When compared to the other studies, the key observations are that:

- the road-traffic noise sample shows a greater annoyance sensitivity than the WHO 2018 guidelines (black ERF curves) and the Miedema and Oudshoorn (red ERF curves) analysis
- the railway ERF relationship closely matches the Miedema and Oudshoorn analysis although it was lacking in the number of highly annoyed subjects
- the aircraft ERF relationship is nearly identical to the WHO 2018 guidelines.

The WHO 2018 guidelines [1] demonstrated a higher exposure response than Miedema and Oudshoorn [9], which implies a general increase in sensitivity to transportation noise over the last 20 years. While the 2022 study showed a greater exposure response than that found by Humpheson and Wareing [2], it was also significantly greater in scope than that study, covering both a larger geographic area and a greater number of respondents. Given the known influences of factors unrelated to noise exposure level, it would not be possible to identify if any differences were a factor of a change in noise sensitivity of the New Zealand population or opinions local to the area surveyed by Humpheson and Wareing [2].

The road-traffic sample results indicate that people are much more sensitive to road-traffic noise in New Zealand than in Europe [1], [9]. It is hypothesised that this may be due to individual events as respondents were asked *'What is it about the road noise that bothers you?'* – 59% of the highly annoyed road-traffic sample were bothered by vehicles driving past their home after 10pm and approximately one-half were annoyed by noisy cars, trucks and/or motorbikes. Other factors may also contribute such as differences in noise character arising from factors such as road surface type and age of vehicles in New Zealand.

All sample groups had greater numbers of subjects in lower noise exposure ranges. This is to be expected as land-use planning controls are well established in New Zealand to restrict noise-sensitive development at high noise levels (greater than 60–65 dB $L_{den}$). Unlike other studies, the relationships at some higher noise levels could not be derived (although extrapolation of the relationships outside the range of noise exposure data was undertaken). A particular limitation was in the railway noise sample. Relatively few people registered high levels of annoyance from railway noise in the higher noise exposure ranges. The combination of a small sample exposed to high levels of railway noise and a low exposure response meant the total number of people highly annoyed was very small thereby reducing the statistical robustness of the ERFs at high noise exposure levels.

Unlike the findings of Humpheson and Wareing [2], this study investigated the response to transport noise at different times of the day and differences between weekdays and weekends. A common theme across all three modes was that transport noise was more annoying at night. The railway sample had a higher proportion of respondents being annoyed between 11 pm and 7 am than the other two modes. Between two-thirds and three- quarters of highly annoyed respondents considered that the noise was annoying regardless of the day of the week, and the remaining respondents considered that the noise was more annoying on weekdays than at weekends. ERFs have not been prepared to determine the time-of-day effects of annoyance and noise exposure level as the number of respondents reporting annoyance in the different time periods is relatively small – for example, the time of day analysis for the railway sample would have been based on approximately 20 responses.

**Uncertainties**

Uncertainty is present both in the estimation of the noise exposure levels at individual dwellings and the derivation of the percentage highly annoyed (%HA).

Noise exposure levels at dwellings were calculated using established methods. As with any modelling exercise, the accuracy of the outputs is also dependent on the input data and assumptions. For example, road-traffic noise modelling in New Zealand may have an uncertainty of 5– 8 dB depending on the surface conditions and distance from the road [10], and the Federal Aviation Administration's Integrated Noise Model for aircraft noise has an accepted uncertainty of ±2 dB, before accounting for flight track accuracy, flight profiles and so on.

This research has assumed that each transportation mode has been modelled using best practice and in accordance with the relevant procedures. Best practice would include the use of relevant input data – for example, numbers and types of road-traffic vehicles, passenger and freight trains and aircraft. However the intended purpose of the models may affect the overall level of uncertainty – for example, a strategic noise model will generally be based on more high-level assumptions than a more geographically constrained model. Any uncertainty associated with these inputs is within the uncertainty range of the methodologies (from ±2 dB to ±8 dB).

Figures 10 to 12 include uncertainty ranges both in terms of derived noise exposure level and annoyance response.

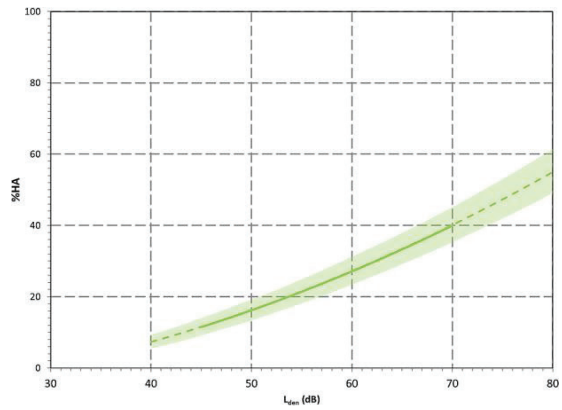


Figure 10. Road-traffic projected ERF curve

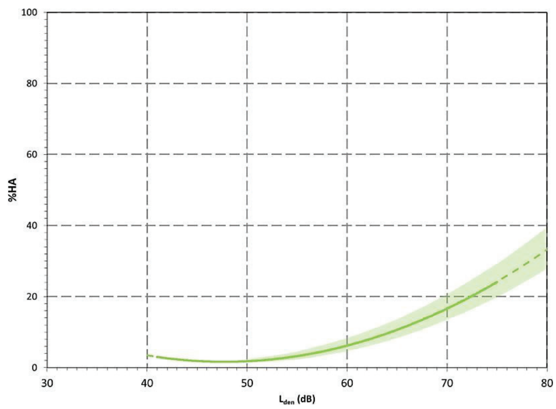


Figure 11. Railway projected ERF curve

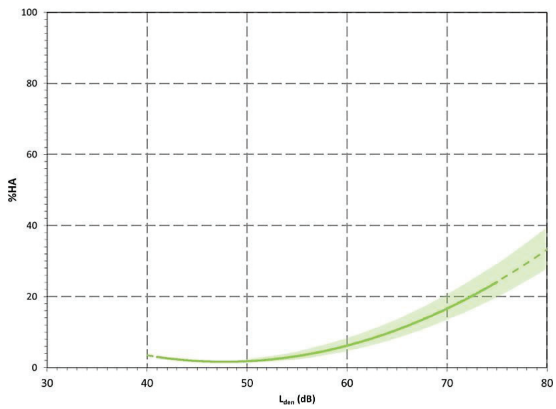


Figure 12. Aircraft projected ERF curve

## Conclusions

The findings of this study can be extrapolated to the New Zealand population exposed to transport noise on the basis that the wider exposed population have on average the same opinions as the sample population.

When compared to the WHO 2018 guidelines [1], the sampled New Zealand population is more sensitive to road-traffic noise, is less sensitive to railway noise and has similar sensitivities to aircraft noise. The study's findings for road-traffic and railway noise are comparable to the findings of the previous New Zealand study [2]. The WHO 2018 guidelines [1] identify that, of the three sources of transportation noise, aircraft noise invokes the highest exposure response followed by road-traffic noise then railway noise. A similar outcome was found for this study.

Socio-acoustic studies have consistently shown that a person's sensitivity to environmental noise varies considerably, that exposure response functions differ depending on the source and that attitudes are also related to non-acoustic factors. Differences could be due to changes in attitudes towards the source of noise, changes in noise exposure, differences in the cultures of those being surveyed, differences in study design, implementation or measurement or a combination of these factors. The influence of these factors should be considered when comparing results from different studies.

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# Evaluating the application of sound level meters in excessive noise enforcement: Feasibility and constraints

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## Abstract

The Resource Management Act 1991 (RMA) regulates noise by requiring every occupier of land to adopt the best practicable option (section 16) to avoid generating unreasonable noise. Councils may establish objective noise limits in district plans, typically based on land-use zones, specific areas, or times of day. Under section 326, councils are also required to manage and respond to excessive noise, commonly referred to as the noise control service, which is assessed subjectively by Council Officers without the need for formal sound measurements or recordings.

This paper evaluates the feasibility, technical constraints, and practical implications of integrating sound level meters into excessive noise assessments. It considers the differences between subjective excessive noise assessment and objective compliance monitoring. It examines relevant New Zealand Standards (NZS 6801:2008 and NZS 6802:2008) and addresses operational, financial, and environmental limitations of sound level meter use in real-world enforcement scenarios.

The study concludes that while technically feasible, the use of sound level meters for excessive noise enforcement is impractical, costly, and could compromise assessment reliability. Also, sound level measurements are not legally required to assess excessive noise.

## What is "Excessive noise"

Section 326 of the Resource Management Act 1991 (RMA) [1] defines excessive noise as any noise that can *"unreasonably interfere with the peace, comfort, and convenience of any person (other than a person in or at the place from which the noise is being emitted)."* The definition explicitly excludes noise from certain sources, including aircraft being operated during, or immediately before or after, flight; vehicles being driven on roads (as defined in section 2(1) of the Land Transport Act 1998); and trains, except when being tested while stationary, maintained, loaded, or unloaded. Subsection 326(2) notes that *"Without limiting subsection (1),* ***excessive noise -****, (a) includes noise that exceeds a standard for noise prescribed by a national environmental standard…"*. In lay terms, this specifically says that if the noise goes above a level set in a national environmental standard, it counts as excessive noise under the law. This means that even if noise does not appear excessive under normal circumstances, it may still be considered excessive if it surpasses legally prescribed standards. However, one of the challenges here is that there are no national environmental standards for noise made under the RMA.

## Determining whether noise qualifies as excessive

When councils receive a formal complaint through their noise control service, the first step is to determine whether the noise meets the legal definition of excessive noise under the RMA. Once confirmed, a Noise Control Officer (NCO) conducts a site visit. As best practice, the NCO should observe and listen to the noise independently of the complainant to allow a neutral assessment. The NCO then makes a subjective judgment on whether the noise unreasonably interferes with others' peace and comfort (s.326). Noise measurements or sound level recordings are not required under the RMA for excessive noise. Assessments rely on the officer's professional judgment, informed by training and oversight from the council's Acoustic Team or Environmental Noise Officers. Factors typically considered by the NCO include, but are not limited to:

- Noise loudness;
- Special audible characteristics;
- Time of day;
- Background sound;
- Land-use zoning (e.g., residential vs. central city);
- Location of both the noise source and receiver; and
- Any additional relevant factors.

The following sections provide details on some of the issues that NCOs deal with.

**Noise relative to background sound:** A key factor is the contrast between the noise being produced (that being investigated by the NCO) and background sound. A loud noise in a quiet area (e.g. suburban street at night) is more likely to be deemed excessive than the same noise in a busy urban or city environment where it may be masked.

**Location of assessment:** Noise must be assessed at the noise-sensitive receiver's location (e.g. a residential property, apartment or similar), not at the source itself. Loudness at the source may not equate to excessive noise at the receiving location, due to screening, buffer distances, and other sound propagation effects.

**Type, character and pattern of noise:** Different types of noise (not just the loudness) can have different impacts:

- Broadband (e.g. white noise)
- Impulsive (e.g. bangs or crashes)
- Intermittent (e.g. cycling machinery)
- Continuous
- Low-frequency (e.g. bass)

Sudden or irregular noises may be more disruptive, even at similar volume levels.

**Special Audible Characteristics (SAC):** SAC is a sub-category of the type or characteristic of noise. Noise with special audible characteristics (such as tones, impacts, screeches, bass, or impulsive traits) is considered more intrusive and may result in adverse community responses at lower volumes than noise without SAC features.

**Nature and purpose of the activity:** The function of the noise source is also important. Activities that serve a public benefit, such as roadworks or community events, may justify higher noise levels if suitably managed and limited in duration. In such cases, enforcement may not be the appropriate first step.

**Sensitivity of the receiving environment:** The acceptability of a noise depends on the type of land use or facility affected. Noise that may be acceptable in an industrial or commercial area could be unreasonable near hospitals, schools, or residential areas, where a higher amenity is expected. As a side note, the zoning of an area also influences assessment. For example, someone may reside in a central city apartment that is not officially zoned as residential. In such cases, the occupant should anticipate higher noise levels (day or night) compared with those in quieter, residentially zoned areas.

**Time of day:** Noise is assessed differently depending on the time it occurs. A sound that may not interfere during the day could be considered excessive if it occurs at night when ambient levels are lower and people expect quiet or are trying to sleep. For example, music played during a daytime party may not be considered excessive; however, the same music at 11 pm is more likely to be deemed excessive due to the lower background noise at night, and most people will be trying to sleep.

**Day of the week or public holiday:** Similarly, noise that may be tolerable on a weekday might be more disruptive on a weekend or public holiday when people are more likely to be at home or resting.

**Duration of the noise:** The length of time the noise is present affects the assessment. Brief, one-off sounds like an alarm that stops after a few minutes, may not be considered excessive, even if loud. However, if the alarm repeatedly goes off throughout the night, this may be deemed excessive.

**Complaint history:** Whether the noise is a first-time occurrence or part of an ongoing issue can influence enforcement decisions. Persistent issues often require a more robust response.

**Number of complainants:** Multiple complaints from different individuals or properties can support a finding that the noise is excessive, indicating a broader community impact.

In conclusion, the determination of excessive noise is a subjective judgment based on context, characteristics, and community impact, rather than any objective acoustic measurement. An NCO is expected to apply practical, fair, and balanced discretion when making such assessments, and above all, be neutral. Experienced NCOs may respond to dozens of calls in a week, hundreds in a year, and thousands over the course of their careers, resulting in a high level of professional judgement.

## What is "Unreasonable noise"?

Determining the difference between excessive and unreasonable noise is a common question, especially from members of the public. The term **"reasonable noise"** itself isn't explicitly defined in the RMA. Instead, the concept comes through in two key parts:

1. Section **"16 Duty to avoid unreasonable noise**
   (1) Every occupier of land (and every person carrying out an activity), ..., shall adopt the best practicable option to ensure that the emission of noise does not exceed a reasonable level."

This is in effect the RMA's general "reasonable noise" requirement.

Under the RMA, local authorities (regional or district councils) set rules and requirements in District Plans and Regional Plans to manage land use and other activities that affect the environment.

2. **District Plan Standards and Rule**
   o Councils set permitted noise limits in their plans (in decibels). Noise that complies with those limits is generally treated as reasonable.

For example, a typical District Plan might set noise limits for a residential zone as a function of level and time as follows:

*Noise from activities within the Residential Zone shall comply with the following noise limits, as measured within the boundary of any site within the specified receiving zones, other than the noise emission site:*

*7:00 am to 10:00 pm: 55 dB* $L_{Aeq\ (15\ minutes)}$

*10:00 pm to 7:00 am: 45 dB* $L_{Aeq\ (15\ minutes)}$

*10:00 pm to 7:00 am: 75 dB* $L_{AFmax}$

*Measurements must be made in accordance with the requirements of NZS 6801:2008 Acoustics – Measurement of environmental sound [2], and NZS 6802:2008 Acoustics – Environmental noise [3].*

District plan noise limits may not apply to all activities in a zone; they are generally specific to activities that are permitted or anticipated in the zone. For example, the Residential Zone noise limits in the example above authorise a noise level of 55 dB $L_{Aeq(15\ minutes)}$ from 7.00 am - 10.00 pm. This limit would not be appropriate to apply to a noise source that is not permitted or anticipated in the Residential Zone.

A key point is that the council's Acoustic Engineer or Environmental Noise Officers assess compliance with the noise limits set out in the District Plan by taking measurements with a sound level meter. In comparison, front-facing assessment of excessive noise complaints is generally handled by NCOs (though not exclusively). To evaluate noise against District Plan limits, objective measurements are required. Assessment is carried out in accordance with the two base New Zealand acoustics standards. These are summarised below:

***NZS 6801:2008 Acoustics – Measurement of environmental sound*** provides the standardised methods for accurately measuring environmental noise. It covers how to use and calibrate sound level meters, where to position microphones, and how to measure different types of sound, such as continuous, intermittent, or impulsive noise. Following this standard ensures that all measurements are reliable, repeatable, and comparable, a key requirement for any compliance or enforcement.

***NZS 6802:2008 Acoustics – Environmental noise*** sets out procedures for the assessment of noise, and how to interpret noise measurements to determine whether noise is unreasonable or exceeds regulatory limits. It provides guidance on comparing noise against background levels, accounting for day and night periods, and considering special noise characteristics. Together with NZS 6801, it forms a complete framework: NZS 6801 tells you how to measure the sound, and NZS 6802 tells you how to assess its impact.

## Key differences between excessive and unreasonable noise

**Excessive noise**

- *Assessment is **subjective**, focusing on whether noise "unreasonably interferes with the peace, comfort, and convenience of people".*
- *Evaluation relies on procedures specifically designed **not** to require the use of sound level meters.*
- *Determined by NCOs using professional judgment, discretion, and experience.*
- *Assessment factors include noise relative to the background sound, the type and character of noise, time of day, location, zoning and other factors.*
- *Typically applied to immediate or temporary noise issues (e.g., parties)*
- *Is cost-effective and does not require expensive equipment, specialised training, or high levels of resourcing.*

**Unreasonable noise**

- *Assessment is **objective**, typically focusing on whether noise exceeds set limits defined in council plans or in resource consent conditions.*
- *Evaluation requires procedures involving Class 1 sound level meters and formal technical measurements.*
- *Determined through objective assessments by qualified and experienced acoustic professionals, following NZS 6801 and NZS 6802.*
- *Considers zone type, time, duration, noise character, and compliance with planning rules for long-term or continuous noise sources.*
- *Requires expertise through specialist training, staffing, equipment, and resourcing.*

A distinct and important difference between unreasonable noise and excessive noise is that excessive noise can apply from *"…any place…"* (s.327(1)(a) ) and is assessed to *"…unreasonably interfere with the peace, comfort, and convenience of any person (other than a person in or at the place from which the noise is being emitted)…"* (s.326(1) ). This means that the NCO can assess the noise from any place, other than the place where the noise is emitted. For example, if the officer is investigating a noisy party at 2 am, they do not necessarily need to assess from the complainant's property. They can assess from any place, including the roadside. Assessments of unreasonable noise under section 16, the district plan noise limits or consent conditions, require the noise to be assessed at a separate site, i.e. *measured at or within the boundary or notional boundary of any site*. The clear intent of s.16 is to limit emissions of noise from land to reasonable levels.

## Alternative methods to assess excessive noise

The above discussion highlighted the key differences between the subjective assessments of excessive noise and the objective assessment of unreasonable noise. The following section explores alternative approaches to evaluating excessive noise and the associated challenges.

**Changes to the excessive noise provisions:** The RMA sets out specific procedures for the assessment of excessive noise (s.326–328). These provisions are explicit and do not require the use of a sound level meter, as the assessment is inherently subjective.
Introducing an objective measurement approach would require amendments to the RMA, and such amendments would be significant. It is worth noting that the noise provisions of the RMA reform of the sixth Labour Government (2017-2023) in the (repealed) Natural and Built Environments Act (NBEA) were largely taken directly from the RMA, with only minor changes.

**Noise limits and assessment:** Objective sound level measurements are typically compared with the permitted noise limits specified in District Plans or Resource Consent conditions. If excessive noise were to be assessed solely by reference to sound level meter measurements, this would first require the establishment of explicit noise limits. Without such limits, the purpose of undertaking measurements would be unclear. Beyond setting limits, procedures would also be required to define appropriate measurement locations and assessment methodologies. These requirements are already addressed through the objective noise limits contained in District Plans and the associated procedures set out in the relevant acoustic standards.

**Significant cost to council and rate payers:** The implementation of suitable Class 1 sound level meters for excessive noise assessments would impose substantial costs. Compliance measurements require a Class 1 sound level meter, although in some cases, such as excessive noise assessment, a less expensive Class 2 meter may be considered. Class 1 meter's range in cost from $4,000 to $25,000, depending on *functionality*. Lower end units may not be deemed suitable for Council compliance assessments. The meter also requires a tone calibrator (cost up


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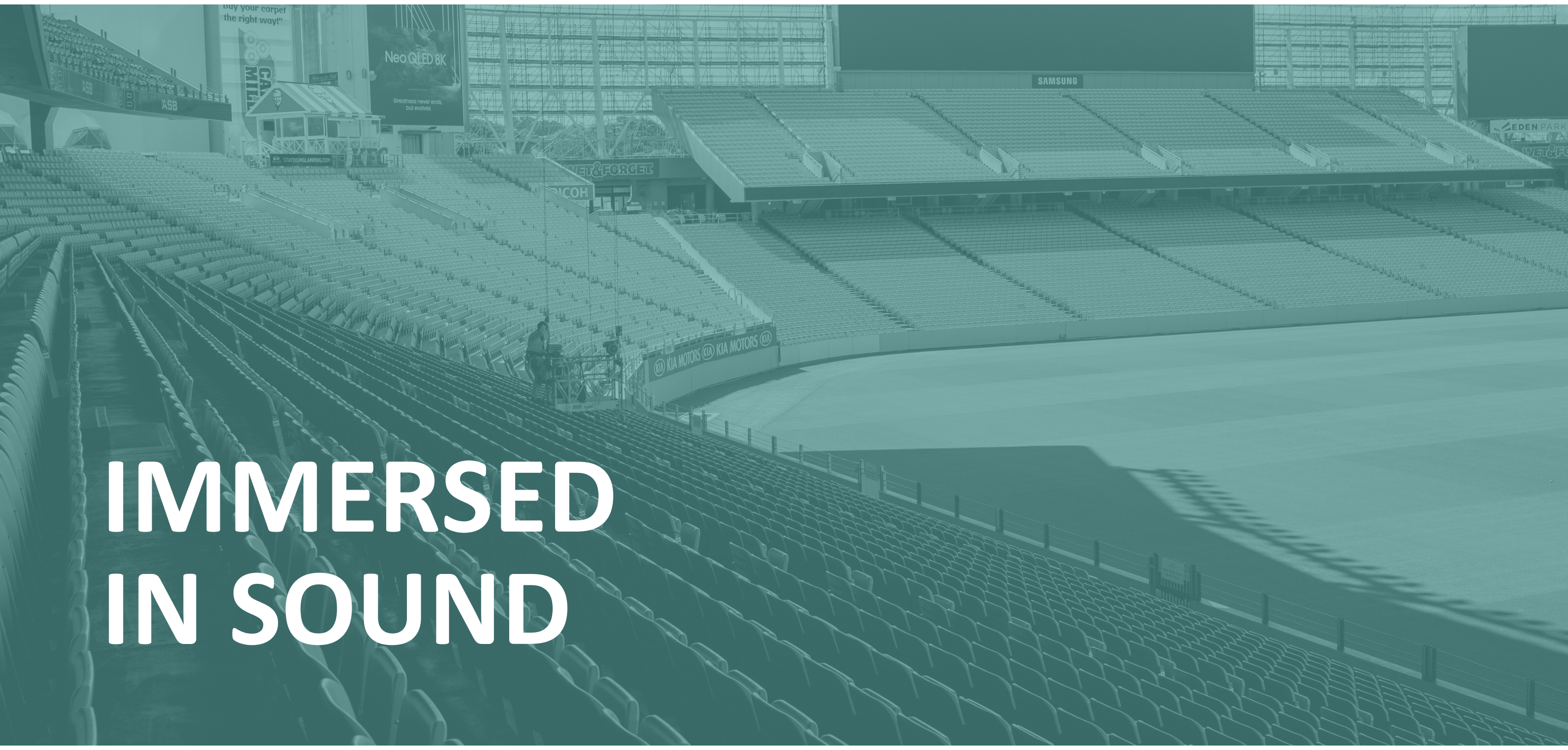


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to $1,100), and both meter and calibrator must undergo periodic (annually for calibrators and every two years for the sound level meter) verification by an accredited laboratory (cost up to $2000 every two years). Additional equipment, such as tripods, protective heavy-duty cases, and administrative requirements, including recording and storing results, further significantly increases costs and resource demands.

For smaller districts, a single sound level meter and calibrator may be sufficient, whereas in larger cities, multiple units may be required. The initial capital outlay is therefore substantial, with ongoing annual costs also significant, especially given the typical 10–15-year service life of a meter. Continuous use during standard NCO shifts would accelerate wear and reduce the service life of equipment, likely below 10 years. Additional costs arise when equipment is unavailable for servicing (necessitating substitute units) or when meters are damaged and require replacement.


**Use of low-cost sound level meters:** Although there is no universal definition of a *'low-cost sound level meter'*, it could generally be described as a unit priced significantly lower than either Class 1 or Class 2 meters (typically costing $50–$500). Potentially making low-cost meters suitable for basic noise surveys, educational purposes, or general sound level monitoring, but **not** for formal enforcement or regulatory compliance measurements. Paired with a tone calibrator, a low-cost sound level meter can be useful for assessment and gauging the approximate noise levels. However, their accuracy, reliability, and credibility are limited, which is critical when measurements are used for compliance or enforcement purposes, including excessive noise.

In practice, compliance monitoring requires Class 1 sound level meters, which are type or pattern-approved and conform to recognised international standards. Conformance indicates that the manufacturer claims the meter meets a standard (e.g., IEC 61672:2013 Electroacoustic - Sound level meters [4]). Whereas pattern approval means the instrument has been independently tested and certified by an accredited laboratory. For example, a low-cost meter purchased online may be advertised as *'Compliant with IEC 61672...'* or *'Designed to meet IEC 61672...'*, which only reflects the manufacturer's claim rather than independent verification. By contrast, Class 1 (or Class 2) meters from professional manufacturers are type or pattern-approved by laboratories such as PTB (Germany) or NPL (UK), with full verification, certification, and traceable documentation. This formal approval process typically costs hundreds of thousands of dollars.

Class 1 instruments are designed to meet strict international tolerances and are calibrated using reference standards to ensure measurement accuracy. Low-cost meters are unlikely to be type/pattern-approved, usually lack laboratory calibration, and do not guarantee accuracy across the frequency spectrum. Testing has shown that they can produce misleading results, particularly in overall sound level and at very low or very high frequencies. Additionally, low-cost meters typically measure only F-time weighted sound pressure levels (SPL) rather than integrated levels. Integrated measurements, such as $L_{Aeq}$ over 15 minutes, represent the average energy of fluctuating noise, reflecting the total exposure to a listener. Whereas, F-time weighted sound levels provide only a momentary snapshot of the noise, which is not generally suitable for compliance assessments. Furthermore, low-cost meters often may not measure frequency content accurately, especially at low frequencies, which are commonly the subject of complaints under s.326. Their performance can also be unreliable under windy, wet, or high-temperature conditions, leading to readings and equipment vulnerability. Consequently, relying on inexperienced operators using low-cost meters for enforcement could result in under- or overestimated sound levels and potentially inaccurate compliance actions, undermining the objectives of Council enforcement procedures.

**Use of mobile phones and Apps:** An alternative to low-cost sound level meters is a mobile phone with a sound measurement App. Like low-cost sound level meters, mobile phones and related apps have significant limitations when used for compliance noise measurements. A standard tone calibrator can usually be used with a low-cost sound level meter, but it cannot be used to check the calibration of a mobile phone. Reviews [5] have shown that sound level measurements made using a calibrated high-end mobile phone can achieve close to Class 2 performance with a suitably skilled and qualified operator under controlled conditions. Unlike Class 1 sound level meters, mobile phones lack precision microphones, preamplifiers, and windshields, all of which are critical for accurate measurements. Mobile phone microphones are designed for voice frequencies and close-up sound, making them unreliable for environmental sound measurement. They cannot replace Class 1 sound level meters for compliance or enforcement purposes.

In summary, while low-cost sound level meters and mobile phone apps can be useful for raising awareness or conducting informal surveys, their significant limitations and potential for inaccurate measurements mean they cannot replace Class 1 sound level meters for professional, regulatory, or compliance noise assessments, nor can they be relied upon for assessing excessive noise.

**New Zealand Standards:** When conducting sound level measurements, including those using a sound level meter for excessive noise, best practice is to follow New Zealand Standards NZS 6801:2008 and NZS 6802:2008. These technical standards provide guidance on determining whether noise is unreasonable or exceeds set limits. They are intended for trained professionals and require a minimum level of practical, technical, and analytical expertise, including mathematical skills and a fundamental understanding of acoustics, all of which take time to develop.

**Training of NCOs:** The standards outlined above include numerous requirements that operators must understand and apply when measuring noise. For example, correctly accounting for non-target sounds, such as background noise, is essential, as failure to do so can artificially inflate measured levels of the target source and lead to inaccurate assessments or misleading compliance findings. This is just one example of the professional judgment and technical skill required when using a sound level meter for excessive noise. In addition to the use of the standards, NCOs would require training in proper use of the sound level meter, data storage, result retrieval, and reporting, all of which are necessary to ensure reliable and defensible noise assessments. Training and regular competency evaluation of NCOs would be required, and this would impose additional costs and resourcing. It is further noted that it is not considered appropriate for NCOs to undertake sound level measurements, review district plan noise limits or apply the requirements of NZS 6801 and NZS 6802 when assessing excessive noise. However, councils may implement measures to utilise NCOs in investigating complaints and, to some extent, act as an additional set of *'eyes and ears'* for the council, without undertaking formal measurements or assessments.

**Time:** Conducting accurate, reliable, and repeatable sound level measurements for any form of compliance or enforcement is a time-intensive process. A single enforcement measurement on-site is often planned and takes an hour or more when carried out by an experienced, qualified operator using a Class 1 sound level meter. Compliance measurements performed in accordance with New Zealand Standards are typically conducted over a minimum period of 15 minutes and are often repeated multiple times to ensure accuracy, repeatability, and a representative assessment of the noise source.

**Weather conditions:** In accordance with NZS 6801:2008 and NZS 6802:2008, sound level measurements must be conducted under suitable weather conditions, often referred to as the "meteorological window". This generally requires stable, dry conditions with calm or light winds. Achieving these conditions can be challenging, especially in locations such as Wellington. Measurements taken during unsuitable conditions may produce unreliable or inaccurate results. For assessments of excessive noise, assessments must be carried out at any time. Attempting measurements in all weather conditions would compromise accuracy. Exposure to moisture, even minor, can alter the sensitivity of a sound level meter, preventing repeatable and reliable readings. Water or moisture can also damage the microphone capsule and internal electronics, which are extremely sensitive, potentially leading to costly repairs or replacement. Therefore, adherence to appropriate weather conditions is essential to maintain the integrity of measurements and protect the instrument. This would not always be practical for excessive noise assessment if the use of a sound level meter was adopted.

## Final comments

The purpose of this paper was to evaluate the application of sound level meters in excessive noise enforcement. While it is possible to use a sound level meter to assess excessive noise, in the opinion of the authors, this approach is impractical, costly, technically challenging, and inappropriate for excessive noise compliance purposes. The RMAs' provisions are inherently subjective for valid practical reasons. They do not require objective measurements, and adopting sound level meters would require establishing explicit noise limits and procedures, such as those used for unreasonable noise assessments.

Class 1 meters, required for accurate and defensible compliance measurements, are expensive, time-intensive to operate in accordance with acoustic standards, and must be used by a suitably qualified and experienced person to ensure reliable results. Low-cost sound meters and sound measurement mobile phone Apps lack the precision, calibration, and reliability needed for compliance.

Accurate measurements also depend on stable weather conditions, proper calibration, and careful accounting for background noise (among other things), all of which are difficult to guarantee in real-world enforcement scenarios. The high cost of Class 1 meters and associated calibration equipment, ongoing maintenance, and staffing requirements is likely to make their use prohibitive for councils.

Excessive noise must be assessed 24/7, any day of the year. Exposure of sensitive sound measurement equipment to environmental factors such as moisture or high winds can damage it and/or produce inaccurate results. For these reasons, and many others set out in this paper, it is the opinion of the authors that sound level meters cannot practically be used as part of the subjective assessment tool kit for excessive noise.

Since a NCO can assess the noise from any place (other than the place where the noise is emitted), if noise limits were introduced for excessive noise and/or if NCOs were required to carry out measurements, the assessment position would likely be required to be at the complainants property, which is impracticable, especially when responding reactively in the middle of the night. Investigations of unreasonable noise complaints tend to be proactive, and the required measurements (at or within the receiving site) are often done by prior appointment by suitably qualified and experienced persons such as Councils Acoustic Engineer.

Also, many councils in NZ are serving abatement notices under s.322(1)(c) for a breach of s.16 using s.326 subjective excessive noise investigations as primary evidence (no sound level measurements). For example, councils are serving an abatement notice for unreasonable noise after five excessive noise directions are served. The abatement notice is enforced if excessive noise continues. There are various legal opinions on this, but it is unlikely that excessive noise was intended to be used as evidence of a breach of s.16 or be used as evidence for s.322(1)(c) abatement notices. There are significant differences in the evidence threshold required for s.16 enforcement compared to s.326 (as this paper clearly sets out). However, there appears to be very little alternative enforcement options available to councils to deal with on-going and repeat excessive noise offending, other than taking a prosecution.

In conclusion, the subjective assessment framework under section 326 of the RMA should continue as the standard approach for excessive noise enforcement. While objective measurements using a sound level meter remain necessary for ensuring compliance with District Plan noise limits and consent conditions, they are not practical, reliable, or cost-effective for assessing excessive noise and are therefore not required for enforcement in such cases.

Finally, the authors are not aware of any substantial evidence indicating that the existing excessive noise provisions fail to achieve the objectives of the RMA.

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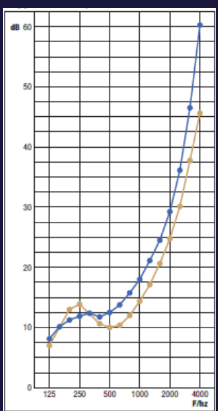



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# Improving surfaces for quieter roads

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## Abstract

Waka Kotahi has been investigating how to reduce road-traffic noise for over 30 years. For most of this time the focus has been on reducing noise from the tyre/road interaction, which dominates road-traffic noise emission. 10 years ago, NZ's first close-proximity (CPX) noise measurements unexpectedly revealed very high longitudinal variability in the noise emission of porous asphalts on the highway network (± 4 dB). Subsequent investigation has revealed the cause of that variability and offered numerous additional insights into what makes porous asphalt quieter than other surfaces, and how it can be made even quieter. The influences of surface texture, porosity, and thickness on tyre/road noise level have been quantified. Each variable has a different influence on the resulting frequency characteristics of road-traffic noise from porous asphalt. This improved knowledge has enabled the development of optimised "high-performance low-noise" asphalt surfaces that are reliably 4 dB quieter than standard NZ porous asphalt and 11 dB quieter than chipseal.

## Introduction

The main source of road-traffic noise at highway speeds is the interaction between vehicle tyres and the road surface. The type of road surface has a large effect on the level of road-traffic noise emission. Between the current noisiest and quietest surface types used on NZ highways there is an 11 dB range [1], all other factors held constant. Surface selection is therefore the most powerful tool available for a road-controlling authority (RCA) seeking to reduce road-traffic noise.

Over the last 30 years, Waka Kotahi has investigated how the road surface materials and design contribute to road- traffic noise emission, how to quantify the effect of different road surfaces on noise, and how to optimise surface specifications to reduce noise [2]. Over the last 10 years this investigation has been greatly aided through use of vehicle-based systems for making close-proximity (CPX) measurements of tyre/road noise emission. Unlike traditional roadside techniques, CPX allows 20-metre resolution of the road surface, efficiently collected at 80 km/h.

The first CPX survey of NZ porous asphalt on the highway network unexpectedly revealed very high longitudinal variability of noise emission [3]. Along lane lengths as short as one kilometre, variations in the region of ±4 dB have been observed, and until recently could not be explained. Since those first measurements, surface noise research led by Waka Kotahi has focused on (i) identifying the mechanisms causing the existing variability, and (ii) developing new porous asphalt surfaces that are both quieter and more consistent.

This paper summarises key findings from the research and development work towards new quiet asphalt surfaces over the last 5 years. A companion paper [4] describes the broader work undertaken to implement the new surfaces in practice on the state highway.

## Road surface influence on noise

The acoustic quantity that an RCA seeks to minimise is the noise exposure of those living near the road, typically measured in dB $L_{Aeq(24h)}$, though special characteristics can also be important. Without control over the vehicles and tyres in the fleet, their influence on that noise exposure is largely through manipulating parameters of road surface construction (such as aggregate size, binder properties, etc) and influencing local propagation of sound using noise barriers.

Optimisation of the surface for noise requires a general understanding of the mechanisms through which each important physical surface property affects tyre/road noise, and which properties are not important. Figure 1 is a simplified representation of how we now understand the dependency of road-traffic noise on surface properties to function in a broad sense. From the wayside noise level, it traces down through the different acoustic mechanisms, to the key surface properties that influence them. The bottom row of the figure identifies just a few of the dozens of construction and material parameters that feed into producing porous asphalts with different physical properties, and hence different tyre/road noise emission. The value of any given construction parameter might influence several different relevant properties of the finished surface (or none of them) but rather than attempt to cover that here, that detail is left to the cited research reports.

The following sections of this paper summarise key findings from research undertaken to quantify the relationships (connections) shown in the figure, which has ultimately enabled new quiet asphalt surfaces to be developed.

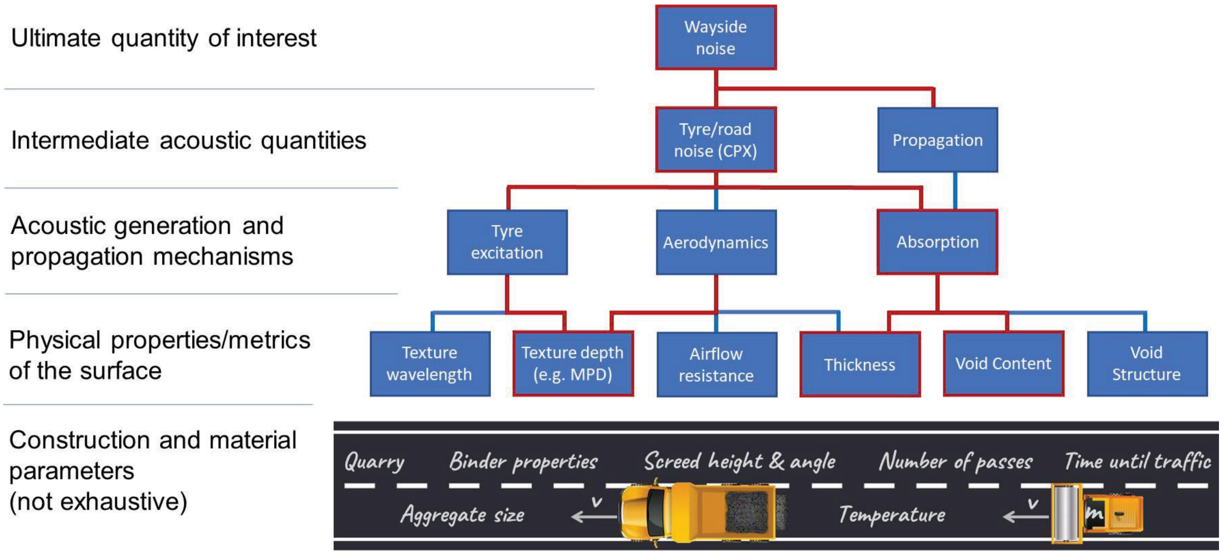


Figure 1. Suggested links from noise level, via acoustic mechanisms, surface properties, to construction and material parameters. Red lines indicate quantified relationships for NZ porous asphalt (omitting the many construction relationships examined).

## Cpx Noise Measurements

Tyre/road noise measurements, in dB $L_{CPX:P1,80,}$ were collected by the Waka Kotahi CPX trailer [5], an ISO 11819-2 compliant measurement system [6]. Several thousand kilometres of state highway were surveyed, with noise data captured at 20-metre resolution. For some specific projects and trial sections, noise and surface parameters (discussed further below) were captured at even higher resolution. The measurements relevant to this paper were mainly made between 2018 and 2024 on Christchurch highway projects WBB, S2G, CNC, CSM2, and on PP2Ō near Wellington.

The relationship between tyre/road (i.e. CPX) and wayside noise levels has been established [7] and is strong but does not fully account for the influence of surface absorption on propagation (Figure 1). Nonetheless it was found that a change in dB $L_{CPX:P1,80}$ due to a different road surface generally results in the same change in dB $L_{Aeq(24h)}$ at the wayside once all factors are considered.

## Tyre Excitation

The physical excitation of the tyre through its interaction with the road surface is a major source of tyre/road noise across all surface types. The interaction itself and its effect on noise generation via tyre distortion is complex and was not directly studied in our research. Instead the key properties of the surface thought to contribute most to tyre excitation were examined for their influence on $L_{CPX:P1,80,}$ the surface macrotexture (texture) depth and wavelength.

Surface texture data were sourced from the annual high- speed data survey of the highway network, and more recently from a laser profilometer fitted to the CPX trailer itself [8] to improve resolution and correlation with the actual path of the CPX tyre.

### Texture Depth

Several metrics and envelopment models for quantifying texture depth of porous asphalt were examined. The relatively simple mean profile depth (MPD) was preferred as it showed equivalent performance as a predictor of noise [9] and is already a NZ industry standard metric. A texture depth influence on tyre/road noise level in the region of +0.7 dB $L_{CPX:P1,80}$ per 0.1 millimetre MPD is suggested [8,10], observed across an MPD range from 0.6 mm to 1.5 mm. The effect was not consistent across the spectrum, being driven solely by low frequencies (400 Hz to 1000 Hz).

In terms of construction materials and processes, the strongest influence we identified on surface texture was the aggregate size [8]. Compared to a nominal maximum aggregate size of 10 mm (average MPD=1.17 mm), a 7 mm aggregate (MPD=0.85 mm) was 2 dB quieter, while a 14 mm aggregate (MPD =1.44 mm) was 2 dB noisier.

Currently a 7 mm nominal maximum aggregate size is considered optimal for noise, and is typically also acceptable for road durability and safety requirements.

### Texture Wavelength

Initial investigations into surface texture wavelength and noise spectra [8] suggest the presence of a correlation, but with influence that is secondary to that of texture depth.

## Tyre/Road Aerodynamics

The movement of air within the tyre/road interface contributes to significant noise generation through air pumping and resonance mechanisms [11]. Especially when tread blocks are large (e.g. some truck tyres), air flow resistance of the road surface should play an important role in whether air gets temporarily restricted at high pressure or can quietly disperse. Air flow resistance of the road surface has not yet been directly studied by this research programme, beyond incidental observations of high frequency effects while investigating texture [9]. The standard P1 car tyre used for CPX may not be the most appropriate tyre for that task due to tread block size.

## Acoustic Absorption

Absorption of sound by the road surface has a strong influence on tyre/road noise in the nearfield, and also on its propagation from the vehicle to the wayside.

Our research suggests the standard CPX microphone positions (45° and 135° incident to the rolling direction of the tyre) adjacent the tyre are only partially sensitive to the nearfield absorption effect [12]. It is hypothesised that porous surfaces are particularly effective at reducing the 'horn-effect' at the front and rear of the tyre, compared to non-porous surfaces, and therefore tyre/road directivity is modified depending on surface acoustic absorption. Combined with additional absorption occurring between the tyre and the wayside, a porous surface may be in the region of 3 dB quieter than a non-porous one at the wayside, for the same value of $L_{CPX:P1,80}$ [7]. Nonetheless the standard $L_{CPX:P1,80}$ parameter retains considerable sensitivity to surface absorption, as will now be discussed.

While our research has included in-situ measurements of acoustic absorption of the road surface [13], it has so far treated this as a discretionary intermediate step between the physical properties of the road surface and tyre/road noise level (see Figure 1).

### Surface Thickness

Our research has found that the thickness of the road surface has a strong influence on tyre/road noise, primarily via its influence on acoustic absorption.

#### Thickness measurement

Direct measurement of the thickness (i.e. depth in millimetres) of finished porous asphalt road surfaces has not been a requirement in NZ. For this research programme, high resolution and accuracy were required, and several measurement methods were considered [14]. Of the trialled methods, LiDAR scans (made before and after the surface is laid) and electro-magnetic induction (metal discs placed at intervals along the road prior to the surface being laid), have provided accurate results [15]. High-resolution thickness data (generally LiDAR) have been measured for three projects, CNC, CSM2, and PP2Ō, and underpin the findings on surface thickness.

#### Thickness effect on noise

The dataset contained similarly-constructed porous asphalt surfaces with a wide range of wheel-path thicknesses, ranging from 20 mm to 65 mm [9,15]. Across all sites and lanes, a strong negative correlation between surface thickness and tyre/road noise exists. The influence on $L_{CPX:P1,80}$ is in the region of -2 dB per 10 mm of surface thickness [10,15], though the relationship is not completely linear (Figure 2).

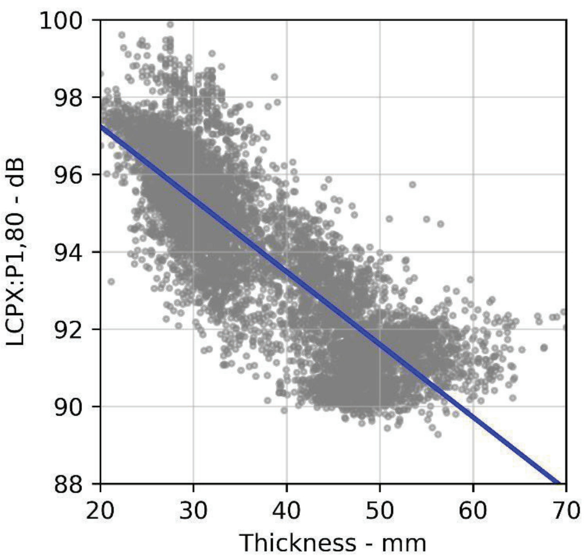


Figure 2: Effect of surface thickness on tyre/road noise (m=-0.19, R2=0.70, n=7122 across 3 projects)

Spectra for similar porous surfaces of different thickness show an intriguing phenomenon [9,10]. As thickness increases, the centre frequency of a broad 'dip' in the typical tyre/noise emission spectrum decreases. At a surface thickness of approximately 50 mm the dip is coincident with the usual tyre/road emission peak at around 800 Hz to 1000 Hz. The apparent 'frequency- tuning effect' of thickness is broadly consistent with a theoretical model for acoustic absorption of porous asphalt [16]. Initial in-situ measurements of acoustic absorption of a NZ road suggest a similar decrease in frequency of peak absorption with increasing thickness [13].

These results demonstrated that increasing surface thickness from the typical range of 20 – 30 mm to 40 mm or 50 mm provides a substantial reduction in tyre/road noise of about 2 dB and 4 dB respectively. The reduction at the wayside may be greater still, due to the unaccounted-for influence on far-field propagation, but this is yet to be confirmed. The observed frequency-tuning effect suggests a limit to the acoustic benefit of additional thickness, applying beyond about 60 mm.

Implementation of a consistently thicker surface requires more material and additional quality controls [4]. We have observed that the surface thickness is sometimes varied during construction to provide a smooth running surface for traffic, and this can have a knock-on effect on tyre/road noise [9].

### Surface Void Fraction

The void fraction, or porosity, of a porous surface has conventionally been considered a critical determinant of its acoustic performance. However, our research suggests that, beyond needing to achieve and maintain some minimum threshold void fraction to function as a porous surface, it is not a strong predictor of the tyre/road noise level of a surface.

The relative void fraction of porous asphalt was measured using a nuclear densometer at 12 independent sites whose average measured void fraction ranged from 10% to 20% (totalling 576 void fraction measurements) [17]. A clear pattern of void fraction influence on tyre/road noise level did not emerge, beyond the suggestion of a local minimum at around 15% voids. Controlling for other variables, the effect on LCPX:P1,80 was weaker than ±0.1 dB per percent void fraction, and non-linear over the expected range of void fraction [10].

There was a correlation between void fraction and surface texture, with higher void fraction tending to have higher MPD and consequently more low-frequency noise [17]. Conversely, higher void fraction tended to reduce high- frequency noise, probably due to aerodynamic mechanisms.

While there is logically some minimum porosity that must be maintained by a surface to achieve acoustic absorption, over the typical range tested (10-25% voids) it was not a fruitful avenue for surface optimisation.

### Surface Void Structure

The length and shape of the interconnected voids in porous surfaces is suggested by theory to influence absorption in a similar way to surface thickness [16]. However, detailed study of these surface parameters is very difficult in practice and has not yet been attempted in NZ with respect to noise.

## Optimising for a quiet surface

Of the studied road surface properties, surface thickness and texture depth have a dominant influence on tyre/road noise of porous asphalt, with other properties having at most a secondary role. The most reliable and effective means of reducing texture depth is to select a relatively fine aggregate for the asphalt mix, thus a nominal maximum aggregate size of 7 mm is preferred (the smallest permissible size). Surface thickness can be controlled at the time of construction, provided the bituminous mix has the appropriate properties, acknowledging there is some tension between acoustic and ride quality demands. A consistent thickness of 50 mm appears close to optimal for porous asphalt that is based on a 7 mm aggregate, while a 40 mm thickness provides a reduced, but still good performance, and uses slightly less material.

It follows that two new high-performance low-noise surfaces have been developed, with thickness and mix designations[1],

- **50 mm EPA7**, with typical noise reduction 4 dB better than standard porous asphalt [1]
- **40 mm EPA7 / PA7,** with typical noise reduction 2 dB better than standard porous asphalt [1]

## Variation in tyre/road noise

Multiple non-linear regression of surface thickness, texture depth (via MPD), and void fraction on $L_{CPX:P1,80}$, where all four metrics were available, produced a relationship that accounted for 89% of the variation in the sample (n=334) [10]. Previous sections described approximate tyre/road noise sensitivities for thickness (-2 dB / 10 mm), texture depth (+0.7 dB / 0.1 mm MPD), and void fraction (< ±0.1 dB / % voids). Across the eight to twelve projects/sites for which data was available and a single surface specification was used, typical variations in those quantities were 4.64 mm thickness, 0.064 mm MPD, and 1.63% voids, given here as standard deviations. Figure 3 therefore provides the anticipated relative influence of each surface parameter on tyre/road noise variation within a single porous asphalt mix designation on a 'typical' project.

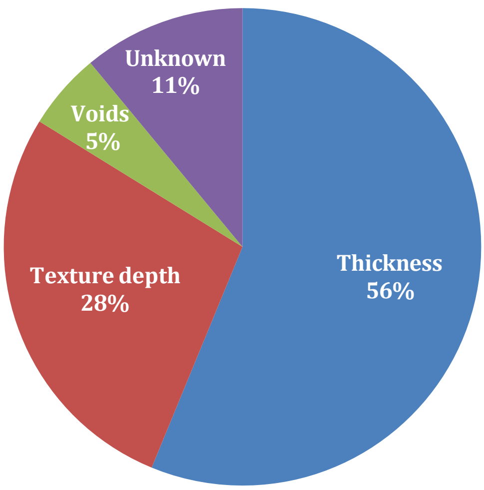


Figure 3: Relative influence of road surface parameters on noise level variation within a single site and surface type

Revisiting the observed high variability of porous asphalt already on the state highway network [3], we now believe this to be principally due to variations in surface thickness [15,18], with a secondary contribution from texture depth. This is not easily proven retrospectively across the full highway network due to the absence of existing thickness measurements and the difficulty of performing the measurements post-construction. Nonetheless, the observed variation in LCPX:P1,80 on the network is consistent with the current findings for thickness variation, having already excluded texture depth and a number of construction parameters as being the primary cause [18].

## Conclusions

Through a structured programme of research (Figure 1), the factors that influence the tyre/road noise emission of porous asphalt have been better understood, and in many cases quantified. Asphalt thickness dominates tyre/road noise variability of porous asphalts, but has been harnessed to produce thicker and much quieter road surfaces. Surface texture depth (measured as MPD) also has a significant effect on noise level, and can be initially controlled through the aggregate sizing. Selecting the (thus far) optimal combination of a 7 mm aggregate and constructing a 50 mm thick porous asphalt surface results in a high-performance low-noise surface that is at least 4 dB quieter than standard NZ porous asphalt.

## Acknowledgements

Many people and organisations have contributed to this research over many years. In particular we acknowledge the contributions from the road surface noise research steering group, the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF) Road Research Centre, and Waka Kotahi colleagues Grant Bosma, Dave Alabaster, Greg Haldane, and Rob Hannaby.

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**For Sound Power measurements to:** ISO 3741:2010, ISO 13261-2: 1998
**Measurement of speech level reduction:** ISO 23351-1: 2020

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# QUIZ

1. What is the speed of sound in air at room temperature (approx. 20°C)?
   A. 100 m/s
   B. 343 m/s
   C. 500 m/s
   D. 1,000 m/s

2. What does Hz (Hertz) measure in acoustics?
   A. Sound pressure
   B. Frequency
   C. Amplitude
   D. Wavelength

3. Which frequency is considered infrasonic?
   A. 10 Hz
   B. 100 Hz
   C. 1,000 Hz
   D. 10,000 Hz

4. What is pitch most closely related to?
   A. Amplitude
   B. Wavelength
   C. Frequency
   D. Phase

5. What kind of filter allows low frequencies to pass?
   A. High-pass filter
   B. Low-pass filter
   C. Band-stop filter
   D. Notch filter

6. What is reverberation time (RT60)?
   A. Time it takes sound to travel 60 meters
   B. Time for echo to occur
   C. Time for sound level to decay by 60 dB
   D. Time for microphone response

7. What is diffraction in acoustics?
   A. Sound absorption
   B. Bending of sound around obstacles
   C. Cancellation of sound
   D. Echo formation

8. What is modal ringing?
   A. Echo delay
   B. Sustained oscillation at a room mode
   C. Speaker distortion
   D. Microphone feedback

9. What is the Nyquist frequency in digital acoustics?
   A. Sampling rate
   B. Half the sampling rate
   C. Double the sampling rate
   D. Cutoff of a low-pass filter

10. What does resonance describe?
    A. Wave cancellation
    B. Sound reflection
    C. Amplification at natural frequency
    D. Diffusion of sound

11. What is masking in psychoacoustics?
    A. Hiding sound behind a mask filter
    B. One sound making another inaudible
    C. Filtering unwanted noise
    D. Sound delay

12. What is the coincidence frequency in wall isolation?
    A. Where wall reflects all sound
    B. Where wall absorbs all sound
    C. Where wall vibrates in sync with sound
    D. Where sound is cancelled by the wall (at 45 degrees)

13. What causes flutter echo?
    A. Absorption
    B. Diffusion
    C. Parallel reflective surfaces
    D. Phase distortion

14. What is interaural time difference (ITD) used for?
    A. Measuring echo
    B. Locating sound direction
    C. Adjusting phase
    D. Eliminating reverb

15. What is transmission loss (TL) in building acoustics?
    A. Sound leakage
    B. Sound reflected
    C. Sound reduction across a barrier
    D. Acoustic gain

16. What is the significance of Kundt's tube in acoustics?
    A. Measures echo strength
    B. Visualizes sound pressure nodes and antinodes using dust
    C. Detects infrasonic waves using dust
    D. Evaluates microphone sensitivity

17. What is the Schroeder frequency?
    A. Threshold of hearing
    B. Transition from modal to diffuse sound field
    C. About the peanut frequency
    D. Equal-loudness contour point

18. What is the Lloyd mirror effect in underwater acoustics?
    A. Echo interference from seabed reflection
    B. Doppler shift under pressure
    C. Sound shielding in shallow water
    D. Thermal diffusion of sound waves

# QUIZ

19. What is the Bark scale used for?
    - A. Reverberation analysis
    - B. Bandwidth division according to critical bands in human hearing
    - C. Measuring phase delay
    - D. Calibrating speakers for classical music

20. What is sonic boom carpet in supersonic acoustics?
    - A. A hard-wearing wool-based carpet
    - B. Zone affected by ground-level sonic boom propagation
    - C. Region of phased interference
    - D. Sonic fatigue region on aircraft

21. What does TLF (Tonal Loudness Factor) correct for in measurement?
    - A. Low-frequency decay above 90 dB only
    - B. Overrepresentation of tonal components in perceived loudness
    - C. Intermodulation distortion and mic phase delay
    - D. All of the above

22. What is the dominant cause of frequency-dependent absorption in air above 10 kHz?
    - A. Viscous losses
    - B. Thermal conduction
    - C. Molecular relaxation (especially oxygen and nitrogen)
    - D. Doppler broadening

23. What characteristic distinguishes a Perfectly Matched Layer (PML) in acoustic FDTD simulations?
    - A. Zero reflection from domain boundaries
    - B. Automatic gain control
    - C. Constant damping across all directions
    - D. Built-in resonator for calibration

24. What is Zwicker's method used for?
    - A. Measuring decibel levels for movie sets
    - B. Psychoacoustic loudness modelling
    - C. Reflectivity simulation
    - D. Reverberation correction

25. What is the function of the characteristic impedance in transfer matrix modelling of multilayer acoustic materials?
    - A. Determines resonant frequency
    - B. Defines reflection and transmission coefficients between media
    - C. Predicts modal density
    - D. Scales pressure gradients for FDTD

26. What is the Theatre of Epidaurus famous for?
    - A. Ancient Greek music theory
    - B. Remarkable acoustics and intelligibility of speech
    - C. Use of stone resonators
    - D. First known binaural recordings

**ANSWERS**

1.B 2.B 3.A 4.C 5.B 6.C 7.B 8.B 9.B 10.C
11.B 12.C 13.C 14.B 15.C 16.B 17.B 18.A
19.B 20.B 21.B 22.C 23.A 24.B 25.B 26.B


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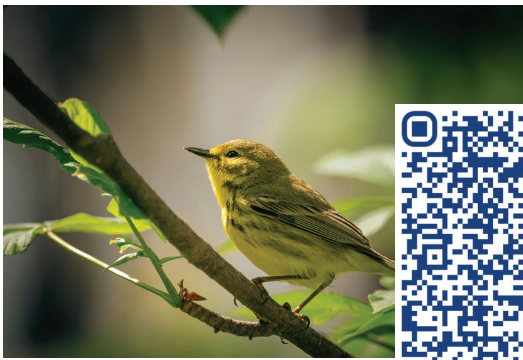
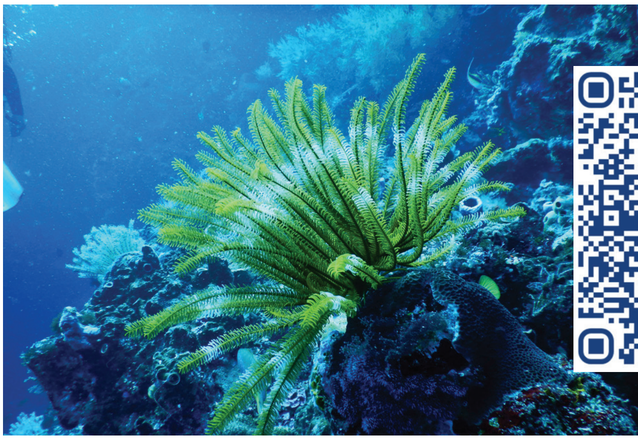


## New acoustic engine BREAKS records! ThermoAcoustsic Heat Power [10]

## No audible boom from first test flight of supersonic passenger plane [11]



## Noise from Vancouver miner's deep-sea operations could threaten Pacific marine life, studies say [12]

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The ASNZ has teamed up with **SoundPrint** to provide this curated list of acoustic ratings for food and beverage venues across Aotearoa (replacing the previous **CRAI** ratings). This data is collated from submissions made by users of the SoundPrint app, which rates venues based on the ambient noise levels present at the time of review and a subjective impression of how easy it was to hold a conversation. SoundPrint ratings follow a decibel scale, and these correspond with our awarded star ratings as follows:

| QUIET | | MODERATE | LOUD | VERY LOUD |
|---|---|---|---|---|
| 70 dBA or below + subjectively “great” for conversations | 70 dBA or below | 70 - 75 dBA | 75 - 80 dBA | 80 dBA or above |
| ★★★★★ | ★★★★ | ★★★ | ★★ | ★ |

The list below contains submissions from the past 3 years only. The numbers in parentheses are the total reviews over this period.

## AUCKLAND

| | | |
|---|---|---|
| &Sushi Smales Farm, Auckland | ★★★★ | (1) |
| Ah Ssak, Auckland | ★★ | (1) |
| Ahi, Auckland | ★ | (1) |
| Albert's Post, Auckland | ★★★ | (1) |
| Ambler, Point Chevalier | ★★★ | (2) |
| Atelier, Auckland | ★★★★★ | (1) |
| Botswana Butchery, Auckland | ★★★★ | (2) |
| BurgerFuel, Auckland | ★★★ | (1) |
| Casablanca Cafe, Auckland | ★ | (1) |
| Casita Miro, Onetangi | ★★★ | (1) |
| Cassia, Auckland | ★★★ | (1) |
| Chamate, Auckland | ★★ | (1) |
| Charlie Farley's, Onetangi | ★★ | (1) |
| Cotto, Auckland | ★★ | (1) |
| Daphnes, Grey Lynn | ★★★ | (2) |
| Dear Jervois, Herne Bay | ★★★★ | (1) |
| Deco Eatery, Auckland | ★★★ | (4) |
| Dizengoff, Ponsonby | ★★ | (1) |
| Ebisu, Auckland | ★★ | (2) |
| Farina, Ponsonby | ★ | (1) |
| Fat Puku’s Smashed Burgers, Auckland | ★ | (1) |
| Gemmayze St شارع الجميزة, Auckland | ★★ | (3) |
| Goat From India, Auckland | ★★★ | (1) |
| Harbour Society, Auckland | ★★★ | (1) |
| Hugo's Bistro, Auckland | ★★★★ | (1) |
| Kingi, Auckland | ★★★ | (1) |
| Kol, Auckland | ★★★ | (1) |
| Little Creatures Hobsonville, Hobsonville | ★★★ | (1) |
| Lokanta Eating House & Bar, Grey Lynn | ★★★★ | (1) |
| Manuka, Auckland | ★★★★ | (1) |
| Masu, Auckland | ★ | (1) |
| McDonald's, Albany | ★★★ | (1) |
| Mr Charcoal BBQ 炭烧时代, Auckland | ★★ | (1) |
| Nanny's Eatery, Kingsland | ★★ | (1) |
| Onslow, Auckland | ★★★ | (1) |
| Pocha, Auckland | ★★ | (2) |
| Prego, Ponsonby | ★★ | (1) |
| Provecho, Auckland | ★★★ | (1) |
| Ragtag, Auckland | ★★★ | (3) |
| Roses Dining Room, Auckland | ★★ | (1) |
| Saint Alice, Auckland | ★★ | (1) |
| Shake Out Smales Farm, Auckland | ★★★★ | (1) |
| Sidart, Ponsonby | ★★★★ | (1) |
| Ssam Jang, Auckland | ★ | (1) |
| Tempero, Auckland | ★ | (1) |
| The Conservatory Bar, Auckland | ★★★ | (1) |
| Tomi Ro Sushi & Robata Grill, Auckland | ★★★★★ | (1) |
| Vondel, Devonport | ★★★ | (2) |
| Wynyard Pavilion, Auckland | ★★★★★ | (1) |

## BAY OF PLENTY

| | | |
|---|---|---|
| Capers Epicurean, Rotorua | ★★★ | (1) |
| Coco's Trattoria, Mount Maunganui | ★★★ | (1) |
| Drift Coffee, Matata | ★★★ | (1) |
| Izakai, Mount Maunganui | ★★★★ | (1) |
| Lloyds Deli & Pizzeria, Tauranga | ★★★ | (3) |
| Macau, Tauranga | ★★★ | (1) |
| Pearl Kichen, Papamoa Beach | ★ | (1) |
| Salinity, Tauranga | ★★★★ | (1) |
| Somerset Cottage, Tauranga | ★★★★★ | (1) |
| The Freeport, Mount Maunganui | ★★★ | (1) |

## CANTERBURY

| | | |
|---|---|---|
| 5th Street, Christchurch | ★★ | (1) |
| BurgerFuel, Christchurch | ★★★★ | (1) |
| C4 Coffee, Christchurch | ★★★ | (2) |
| Cafe Valentino, Christchurch | ★★★ | (1) |
| Coffee Culture, Rangiora | ★★★ | (1) |
| Doubles, Christchurch | ★★★★ | (1) |
| Gatherings Restaurant And Living Wine Bar, Merivale | ★★ | (1) |
| Jinweide Beef Noodle, Christchurch | ★★★ | (1) |
| Khmer Satay Noodle House, Riccarton | ★★★★ | (1) |
| Little Poms, Christchurch | ★★ | (4) |
| Lyttelton Coffee Company, Lyttelton | ★★★ | (1) |
| Mac's South Bar & Café, Christchurch | ★★★★★ | (1) |
| McDonald's, Christchurch | ★★★★ | (1) |
| Meshino, Saint Albans | ★ | (1) |
| Misceo Cafe & Bar, Ilam | ★★★ | (2) |
| Mitchelli's, Christchurch | ★★ | (1) |
| Robert Harris Lincoln, Lincoln | ★★ | (1) |
| Sal's Authentic New York Pizza, Riccarton | ★★★★ | (1) |
| Sherpa Kai, Lyttelton | ★★★★ | (1) |
| Super, Lyttelton | ★★★★★ | (1) |
| The Birdwood, Beckenham | ★★★ | (1) |
| The Garden Brasserie, Riccarton | ★★ | (1) |
| The Laboratory, Christchurch | ★★★★ | (1) |
| The Rockpool Bar, Christchurch | ★ | (1) |
| Two Thumb Brewing Co Ltd, Christchurch | ★★ | (1) |
| Vic's Cafe (& Bakehouse), Christchurch | ★★★ | (3) |

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| | | |
|---|---|---|
| Volstead Trading Company, Christchurch | ★★★★★ | (1) |
| You Hanoi Me, Christchurch | ★★★★ | (1) |
| Zephyr, Kaikoura Central | ★★★★★ | (1) |

## MANAWATU-WANGANUI

| | | |
|---|---|---|
| Café Cuba, Palmerston North | ★★ | (1) |
| Carl's Jr., Palmerston North | ★★★★★ | (1) |
| Little Savanna, Palmerston North Central | ★★★★★ | (1) |
| Spice Guru, Whanganui | ★★★★ | (1) |
| Viv's Kitchen, Sanson | ★★ | (1) |

## MARLBOROUGH

| | | |
|---|---|---|
| Quench Restaurant at Chateau Marlborough, Blenheim | ★★ | (1) |

## NELSON

| | | |
|---|---|---|
| Sprig & Fern Tavern, Nelson | ★★★ | (1) |
| The Free House, Nelson | ★★★★ | (1) |

## NORTHLAND

| | | |
|---|---|---|
| The Gables, Russell | ★★ | (1) |

## OTAGO

| | | |
|---|---|---|
| Bacchus, Dunedin | ★★★ | (1) |
| Big Fig, Wanaka | ★★★ | (1) |
| Blue Kanu, Queenstown | ★★ | (2) |
| Etruscos At The Savoy, Dunedin Central | ★ | (1) |
| Fogo Brazilian Barbecue Experience, Queenstown | ★ | (1) |
| Jervois Steak House, Queenstown | ★★★★ | (1) |
| Jizo Japanese Cafe & Bar, Dunedin | ★★ | (1) |
| My Thai Lounge, Queenstown | ★★★★ | (1) |
| No 7 Balmac, Dunedin | ★★★★★ | (1) |
| Slow Cuts, Arrowtown | ★ | (1) |
| Winnies Gourmet Pizza Bar, Queenstown | ★★★ | (1) |

## SOUTHLAND

| | | |
|---|---|---|
| Bailiez Cafe, Te Anau | ★★★★★ | (1) |
| Ranch Bar And Grill, Te Anau | ★★ | (1) |
| Speights Ale House, Invercargill | ★★★ | (1) |

## TARANAKI

| | | |
|---|---|---|
| Gusto Restaurant, New Plymouth | ★★★★ | (1) |

## WAIKATO

| | | |
|---|---|---|
| Orca Restaurant & Bar, Raglan | ★★★★★ | (1) |
| Robert Harris, Cambridge | ★★★★ | (1) |

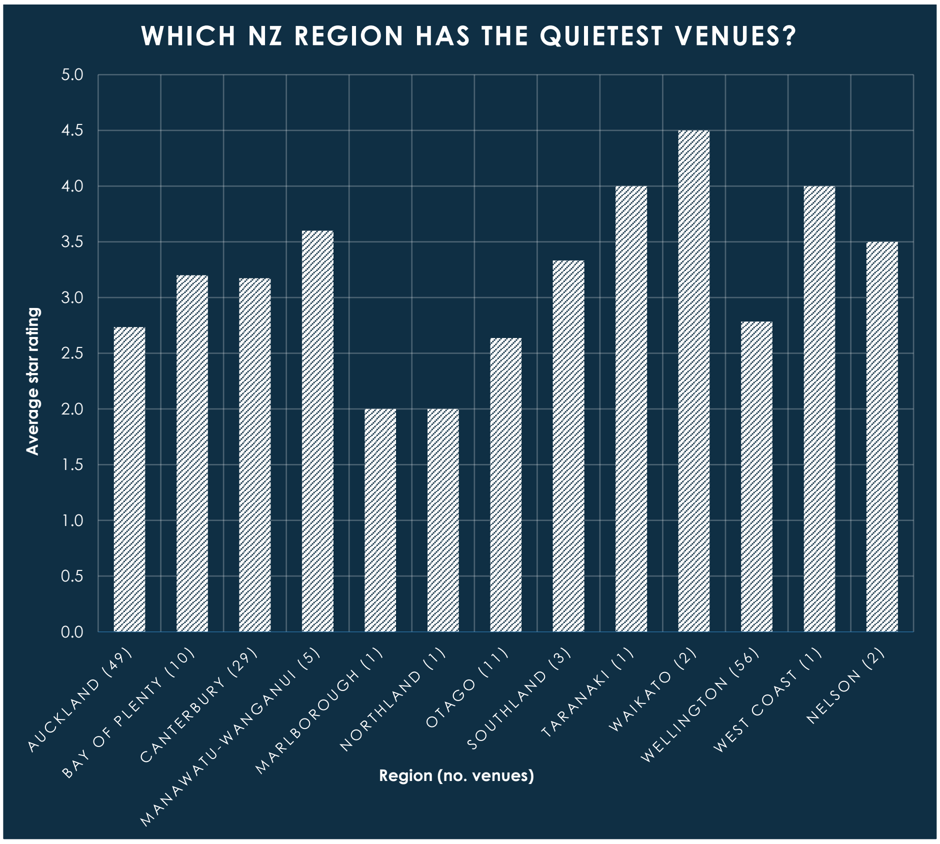
## WELLINGTON

| | | |
|---|---|---|
| 1154, Te Aro | ★ | (1) |
| Abrakebabra, Te Aro | ★★★★★ | (1) |
| Balter Bar & Kitchen, Carterton | ★★★ | (1) |
| Baylands Brewery, Lower Hutt | ★★★★ | (1) |
| Bethel Woods, Wellington | ★★ | (1) |
| Black Coffee, Wellington | ★★★ | (1) |
| Boulcott Street Bistro, Wellington Central | ★ | (1) |
| Brown Sugar Cafe, Otaki | ★★★★ | (1) |
| BurgerFuel, Wellington | ★★★★ | (1) |
| Caffe L'affare, Te Aro | ★ | (2) |
| Cool Change, Martinborough | ★ | (1) |
| Dockside, Wellington Waterfront | ★ | (1) |
| Dragon Fly, Te Aro | ★ | (1) |
| Elements Cafe, Lyall Bay | ★★★ | (1) |
| Flamingo Joe's, Pipitea | ★★ | (1) |
| Fratelli, Te Aro | ★★★ | (3) |
| Fuel Espresso, Wellington | ★★★★ | (1) |
| Glocal Bistro, Upper Hutt | ★★★★★ | (1) |
| Hashigo Zake, Wellington | ★★★★★ | (1) |
| Heaven, Wellington | ★★ | (1) |
| Hola Mexican Cantina, Paraparaumu | ★★ | (1) |
| Indian Alley, Te Aro | ★★★ | (2) |
| Karahui, Martinborough | ★★ | (1) |
| La Bella Italia, Petone | ★★★★★ | (1) |
| Le Bouillon Bel Air, Wellington | ★★ | (1) |
| Le Saigon Vietnamese Kitchen, Wellington | ★★ | (1) |
| Lola Stays, Oriental Bay | ★★★ | (1) |
| Loosies Superette, Wellington | ★★★★★ | (1) |
| Maranui Cafe, Wellington | ★★ | (1) |
| Miyabi, Wellington | ★ | (2) |
| Monsoon Poon, Wellington | ★★★ | (1) |
| Mystic Kitchen, Strathmore | ★★★★★ | (3) |
| Ombra, Te Aro | ★★ | (1) |
| Panhead Tory, Te Aro | ★★★★★ | (1) |
| Pomelo Kitchen And Bar, Oriental Bay | ★ | (1) |
| Poquito, Wellington | ★★ | (1) |
| Prefab - ACME HQ, Te Aro | ★★★ | (1) |
| Preservatorium, Wellington | ★★★★ | (1) |
| Puro Chile, Wellington | ★★ | (1) |
| Rasa, Wellington | ★★ | (2) |
| Revive Cafe, Petone | ★★ | (1) |
| Rose's Red-Hot Cantina & Taco Joint, Wellington | ★ | (1) |
| Seashore Cabaret, Petone | ★★ | (1) |
| Seoul House, Wellington | ★★★★★ | (1) |
| Siam Spoon, Petone | ★★ | (1) |
| Somtum Thai, Te Aro | ★★★ | (1) |
| Te Papa Cafe, Wellington | ★★★★ | (1) |
| The Beanery By Mojo, Wellington | ★★★ | (2) |
| The Chopstick Table, Petone | ★★★★ | (1) |
| The Ram, Te Aro | ★ | (1) |
| The Salt and Wood Collective, Waikanae | ★★★★ | (1) |
| Union Square Bistro, Martinborough | ★★ | (2) |
| Viva México, Lower Hutt | ★★★ | (1) |
| Viva Mexico, Wellington | ★ | (1) |
| Waitoa Social Club, Wellington | ★★★ | (1) |
| Whitby's Restaurant & Piano Bar, Wellington | ★★★★★ | (1) |

## WEST COAST

| | | |
|---|---|---|
| Betsey Jane, Fox Glacier | ★★★★ | (2) |

SoundPrint can be downloaded from the Apple App Store and Google Play Store. More information and reviews are available at the website: https://www.soundprint.co/locations/nz




SoundPrint can be downloaded from the Apple App Store and Google Play Store. More information and reviews are available at the website: https://www.soundprint.co/locations/nz

SiteHive

## Next-Generation SiteHive Hexanodes Deliver Smarter, Simpler Environmental Monitoring

SiteHive, the leader in smart environmental monitoring technology, has announced the release of its next-generation SiteHive Hexanode devices. Purpose-built for construction and operational environments, the innovative devices set a new benchmark for real-time monitoring of noise, vibration and dust.

Developed through years of research and collaboration across industry, the new range offers sharper insights, smarter design, and the same innovation and simplicity that SiteHive is known for. Each device has been re-engineered to improve accuracy, reliability, and usability – all while remaining compact, connected, and cost-effective.

For consultants, SiteHive's devices and software make it easier to service more projects in parallel by saving time and effort on multiple fronts. With new and improved measurement capabilities and certifications, the next generation of SiteHive Hexanodes also provide even more confidence. They deliver deeper insights and analysis that enable consultants to provide better advice to clients, with less effort.

**New capabilities**

The next generation SiteHive Hexanodes enable independent NATA certification for both noise (IEC 61672-3:2013) and vibration (ISO 16063-21:2003) devices from a network of partner-accredited laboratories across Australia, including NVMS and Calibre.

Across the whole family of devices, new 4G, network-roaming and Wi-Fi connectivity ensures reliable access from any site. Each device type also includes specific new capabilities:

- **SiteHive Hexanode Noise+Dust** combines two environmental aspects in one compact unit. The 2-in-1 device streamlines set up and lowers costs.
- **SiteHive Hexanode Noise** has a new spherical design for full 360-degree acoustic performance. A standard interface for pressure calibrators enables in-field calibration, NATA certification by independent labs, and delivers spectral noise data with built-in octave band analysis (IEC 61260.1:2019).
- **SiteHive Hexanode Dust** delivers reliable dust data with a humidity-resistant sensor, 5x airflow improvement, and image and audio capture triggered by dust events.
- **SiteHive Hexanode Vibration** is unique in monitoring three vibration types: structural, human comfort and ground-borne noise, all in one palm-sized unit. New features include automated frequency assessment (DIN 4150-3 and BS 7385-2) and NATA certification via accredited facilities.

All devices connect to **SiteHive Enviro**, a cloud-based software platform where data from noise, dust, vibration, water, and weather can be viewed and managed in a single, intuitive dashboard. Graphical visualisations and event-triggered images and audio make it easier than ever to monitor site impacts and maintain regulatory compliance from any location.

This level of control and insight enables consultants to manage more project sites remotely and simultaneously. The SiteHive technology provides "eyes and ears" on sites, and brings the data and information directly to wherever people are working - be it the office, on site, or anywhere else.

With the new generation of SiteHive Hexanodes, environmental monitoring isn't just smarter - it's simpler, more reliable, and ready for the real-world demands of today's construction, infrastructure and operational projects. SiteHive continues to set the benchmark for smart, simple, and effective environmental monitoring.

info@asona.co.nz

asona.co.nz

asona

# Delivering perfect harmony

Sound isn't just something we hear; it's something we feel. At Asona, we believe in designing acoustic and aesthetic ceiling and wall solutions that go beyond mere sound, to enhance the performance, functionality, wellbeing and enjoyment of spaces.

# UPCOMING EVENTS

## DECEMBER 2025

### 189th Meeting of the Acoustical Society of America (ASA)
**December 1-5 2025**

Honolulu, Hawaii, USA
acousticalsociety.org

### International Conference on Acoustics, Sound and Vibration (ICASV 2025)
**December 1-2, 2025**

Auckland, New Zealand
conferenceindex.org

### International Conference on Acoustics and Applications (ICAA 2025)
**2-3 December 2025**

Tokyo, Japan
conferenceindex.org

### International Conference on Acoustics, Noise and Vibration (ICANV 2025)
**December 20-21 2025**

Honolulu, Hawaii, USA
conferenceindex.org

## MAY 2026

### 190th Meeting of the Acoustical Society of America (ASA).
**May 11-15, 2026**

Philadelphia, Pennsylvania, USA
acousticalsociety.org

### Baltic-Nordic Acoustic
**May 4-6, 2026**

Gothenburg, Sweden
Euracoustics,org

## AUGUST 2026

### 55th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2026).
**August 9-12, 2026**
Adelaide, Australia

inter.noise ADELAIDE SOUTH AUSTRALIA 9 - 12 AUGUST 2026

### International Conference on Acoustics and Vibration (ICAV 2026)
**August 19-20, 2026**

Bangkok, Thailand
waset.org

## OCTOBER 2026

### International Conference on Acoustics (ICA 2026)
**October 7-8, 2026**

Tokyo, Japan
waset.org

## DECEMBER 2026

### International Conference on Acoustics and Vibration (ICAV 2026)
**December 6-7, 2026**

Kuala Lumpur, Malaysia
waset.org

### International Conference on Acoustics and Vibration (ICAV 2026)
**December 16-17, 2026**

Bangkok, Thailand
waset.org

## AUGUST 2027

### International Congress of Phonetic Sciences
**August 9-13, 2027**

Victoria, Canada
https://www inernationalphoneticassociation. org

## DECEMBER 2027

### International Conference on Acoustics and Vibration (ICAV 2027)
**December 6-7, 2027**

Kuala Lumpur, Malaysia
waset.org

### International Conference on Acoustics and Vibration (ICAV 2027)
**December 16-17, 2027**

Bangkok, Thailand
waset.org

**Note:** Dates and information are subject to change. We encourage you to go directly to the source material and event website of each event to ensure you have the latest and most up to date information including dates.

# Akustik R-Clip W50-70 + Sylomer®

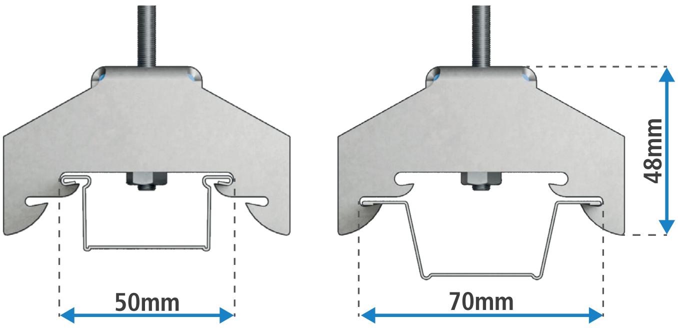
AMC MECANOCAUCHO
Manufacturing **solutions** for architectural acoustics and vibration problems
**since 1969**

The **Akustik R-Clip W50-70 + Sylomer®** is an acoustic hanger designed for ceiling suspension using Omega-type metal profiles.

Its name refers to the width of the two coupling slots (50–70 mm), which **allows it to adapt to different types of Omega profiles**.

Thanks to its design, it offers a versatile, **robust and quick-to-install solution**, ideal for both new constructions and acoustic retrofitting projects.

## One hanger, two slots

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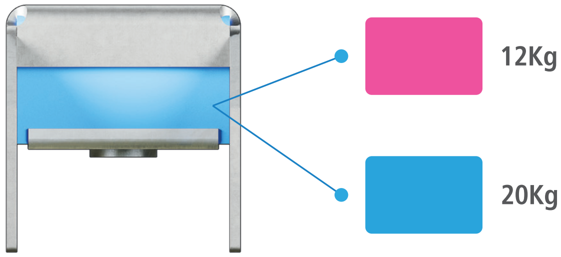


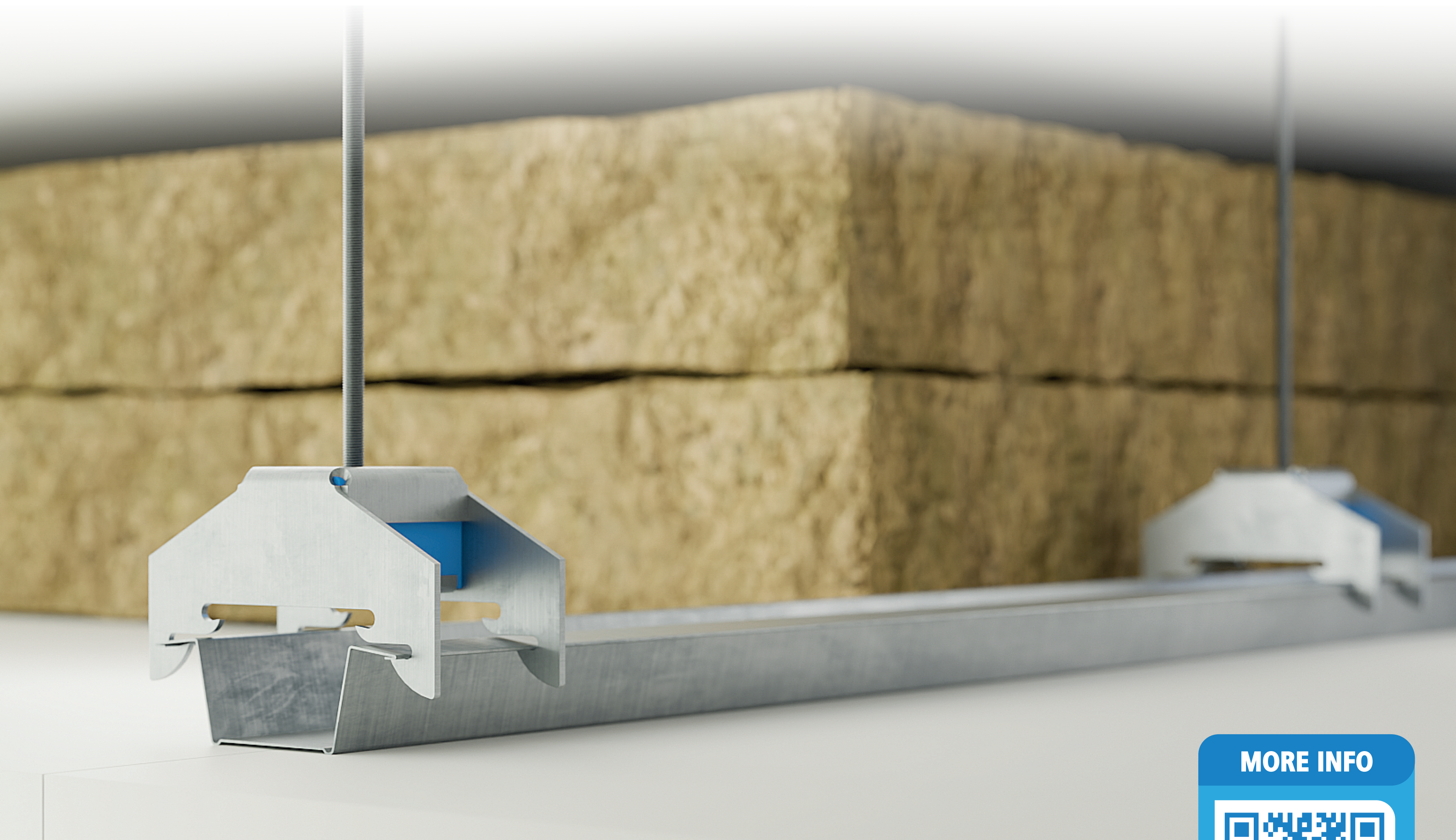

**MORE INFO**

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SiteHive

# Next-generation SiteHive Hexanodes

A new benchmark in environmental monitoring.
Real-time, accurate noise and vibration measurements made easy.

## SiteHive Hexanode Noise

- Can be NATA certified (IEC 61672-3:2013) by accredited laboratories
- Octave band analysis (IEC 61260.1:2019)
- Directional noise monitoring
- Directional images triggered by noise
- AI classified audio identifies activities on site
- In field calibration

## SiteHive Hexanode Vibration

- Can be NATA certified (ISO 16063-21:2003) by accredited laboratories
- Structural (PPV) & Human Comfort (VDV) measurements in one device
- Automated structural frequency assessment (DIN 4150-3 & BS 7385-2)
- Ground-borne noise calculations
- Self-orienting in any deployment

See how SiteHive can make your job easier: sitehive.co

Or scan the QR code to get in touch.