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Memorandum

To:	Richard Jackett, NZTA
CC:	Mike Wood, NZTA
From:	Jonathan Prins, AES
File Reference:	AC20063 – 02 – R3
Date:	Monday, 24 June 2024
Project:	Cost of traffic noise mitigation measures – Existing dwelling extensions and alterations
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Meeting ☐ Telephone ☐ Memorandum ☑ File Note ☐

Dear Richard,

In August 2023, New Zealand Transport Agency Waka Kotahi (NZTA) engaged Acoustic Engineering Services (AES) and O'Brien Quantity Surveying to undertake a study relating to the cost of traffic noise insulation measures in the context of dwelling extension and renovation projects. The project involved a review of a number of real and hypothetical situations where a traffic noise assessment was required during projects involving the extension and/or alteration of existing dwellings, as a result of their location in proximity to major roads.

This memorandum summarises the study, and the general trends visible in the results.

1.0 EXECUTIVE SUMMARY

Acoustic Engineering Services has been engaged by NZTA to investigate the cost of acoustic upgrades required for extensions and/or alterations to dwellings where facades are exposed to traffic noise. The study was based on a sample of 22 different dwellings with planned extensions and/or alterations, and was carried out to assist NZTA in understanding the potential financial implications of mandatory traffic noise insulation rules with regard to dwelling extension and/or alteration projects.

The study found that the proportional cost of acoustic upgrades relative to the total project cost tended to increase with higher external noise levels, and where the original estimated project cost was relatively low. There was a wide variation in the absolute cost of acoustic upgrades, which did not appear to have any correlation to the size of the alterations. The average cost of acoustic upgrades was found to be $21,000, with a standard deviation of $16,000 (NZD, Q1 2024).

The findings in this report provide an understanding of the expected cost of acoustic upgrades for alterations to dwellings near state highways, and give an indication of some of the factors that influence those costs.

2.0 SCOPE

A common method of ensuring that noise from roads is not intrusive within buildings is to design the building envelope to provide a high level of sound insulation, and to provide a mechanical ventilation system so occupants do not need to open windows for cooling and fresh air.

AES have previously completed a study related to the cost of acoustic upgrades in new dwellings (AES file reference AC20063 – 01 – R2). The work described in this memo built on aspects of that previous study.

This new study aimed to quantify the cost of an acoustic assessment and resulting upgrades when these are required in the context of a project involving the extension and/or alteration of an existing dwelling. The purpose of this work was to assist NZTA in understanding the potential financial implications of mandatory traffic noise insulation rules with regard to dwelling extension and/or alteration projects.

3.0 THE SAMPLE

A total of 22 projects involving an extension and/or alteration were considered for inclusion in the analysis. However, detailed costings were only completed on 19 of these, primarily because the subsequent analysis indicated that some of the buildings would not require acoustic upgrades. Overall, the sample was relatively small due to the limited scale of the project, however the variety within the sample is typical of the variety of extensions and/or alterations to existing dwellings that would be expected in New Zealand, in our experience.

The existing dwellings which were the subject of the 22 building projects included 19 detached residential dwellings, and 3 multi-residential units (such as terraced houses and duplexes). The dwellings were expected to experience worst-case traffic noise levels ranging from 57 dB $L_{Aeq\ (24\ h)}$ to 69 dB $L_{Aeq\ (24\ h)}$ on the most exposed facade.

It was found that in almost all cases that extensions to existing dwellings (increases in the footprint) were accompanied by other internal alterations within the existing building footprint. We have used the term 'alteration area' in this memo to refer to the total floor area 'involved' with the building work – typically an addition of some new floor area, and refurbishment/rearrangement of spaces within the original building footprint. 'Alteration areas' in the study spanned from 14 m^2 to 389 m^2, however only one was less than 40 m^2, and three less than 50 m^2.

Some examples from the sample include:

- An extension to a living, dining, and kitchen space (40 m^2 alteration area)
- An alteration to an existing dwelling with a new internal layout and extended area for a kitchen and dining room (120 m^2 alteration area)
- Addition of a new bedroom and extended floor area for the living room, with changes to the internal layout of the house (150 m^2 alteration area)
- Addition to a dwelling to include a garage and extra bedrooms, and changes to the internal layout of the house (205 m^2 alteration area)
- Extension to the kitchen and dining areas in an existing dwelling, as well as an ensuite, walk-in wardrobe, and reception area, changes in use of some internal rooms, and new cladding to the majority of the exterior of the dwelling (389 m^2 alteration area)

It appeared that very small alteration areas were relatively uncommon within the database we had access to. In the case of small 'additional floor area' scenarios, this may be because the practicalities, economics and risk of interrupting, extending, and reinstating the weatherproofing and structural elements of a building are prohibitive when the benefit is only a small increase in floor area. In the case of small 'internal alterations', this may be because Building Consent is not sought, and so there is no official record of these projects.

4.0 METHODOLOGY AND ASSUMPTIONS

The following methodology was used for the study:

- A set of 22 different scenarios for dwelling extensions and/or alteration projects were sourced from previous Acoustic Engineering Services assessments. The majority of the projects were originally undertaken in areas subject to a 'road traffic noise insulation' rule. However, to provide a larger sample, a number of projects were also included which had previously been assessed for noise from aircraft or from a port. For the purposes of the study, these examples were now considered to be 'placed next to' a hypothetical busy road.

- The study assumed compliance was required with a 40 dB $L_{Aeq(24\ h)}$ maximum internal noise rule, which is a measure that has been widely adopted by District Plans in New Zealand, and is also included in NZTA guidelines and the New Zealand Standard NZS 6806:2010 *Road traffic noise*.

- Calculations were carried out for each scenario, and the architectural drawings were marked up with appropriate acoustic upgrades to the modified parts of the building to achieve the internal noise level requirement. As above, the outcome of the analysis in some cases was that no upgrades were required. Sometimes the upgrades were extensive. That is consistent with the range of outcomes we observe in real-life projects.

- The mark-ups above were supplied to a Quantity Surveyor to evaluate the cost of the original extension and/or alteration project depicted in the architectural plans, and the cost the acoustic upgrades would add to this. We added the typical cost of 'review and analysis by an acoustic engineer' to each project. Alternative systems to the systems shown in the mark-ups were not considered.

- Data was collected, and the cost of an acoustic report was added to each sample. The data was analysed to find trends in the cost of acoustic upgrades for alterations to existing dwellings.

The following assumptions are relevant to the 'acoustic analysis' aspect of the study:

- Reported external noise levels are based on the available traffic numbers, road surface, and speed information for the road adjacent to the building project site at the time (or the assumed road in a small number of examples, as above), and are for the most exposed building facade.

- Constructions where not specified in the architectural drawings were assumed to be 10 mm GIB Standard plasterboard internal linings for walls, and 13 mm GIB Standard plasterboard linings for ceilings, and 4 mm float glass / 12 mm air space / 4 mm float glass for glazing.

- Where a 'rigid air barrier' or high-mass internal linings were specified for external walls, it was assumed that they would have been included regardless of the acoustic upgrades.

- The mechanical ventilation system was assumed to require an adjustable airflow rate of up to at least 6 air changes per hour, and achieve 35 dB $L_{Aeq(30\ s)}$ in bedrooms and 40 dB $L_{Aeq(30\ s)}$ in living rooms measured at 1 metre from any grille or diffuser.

The following assumptions are relevant with regard to the 'costing' aspect of the analysis:

- The Quantity Surveyor considered a situation where an acoustic assessment occurs early in the design, and so any recommended acoustic upgrades could be incorporated without major rework to the design.

- Estimates were formed on current market (Q1 2024) m^2 rates for applicable residential building works. This rate would need to be adjusted for inflation when quoted for future applications.

- It was noted that acoustic upgrades could have a knock-on effect on selections of other building elements, particularly where glazing upgrades are required:
    - External glazing upgrades can result in an increase in window suite size to accommodate the glazing thickness.
    - External glazing upgrades can result in an increase in frame thickness to accommodate the glazing weight.
    - External glazing upgrades may result in all windows needing to be upgraded to match the aesthetic.

  The above secondary upgrades have also been included as part of the total acoustic upgrade cost, despite not being directly necessary for traffic noise mitigation.

- It was also noted that where building elements such as windows from the original building were intended to be reused but had to be upgraded for noise mitigation, the cost of the upgrades relative to the original planned building work would increase further. However, it was not possible to account for this in the analysis.

- Buildings on the same site that are built new or not connected to the building alteration used for the study have been neglected for the purposes of this study.

- Dwellings that did not require upgrades were included with the study, with the 'cost of upgrades' being the cost of an acoustic assessment. The cost of an acoustic assessment is included with the acoustic upgrades, but not within the original cost of the overall alteration.

5.0 FINDINGS

We have summarised a number of key observations from the analysis below.

5.1 Relationship between proportional cost increase, and external noise level

The proportional cost of acoustic upgrades relative to the benchmark building costs described above in section 4.0 are plotted below in figure 5.1, excluding one significant outlier (discussed further below).

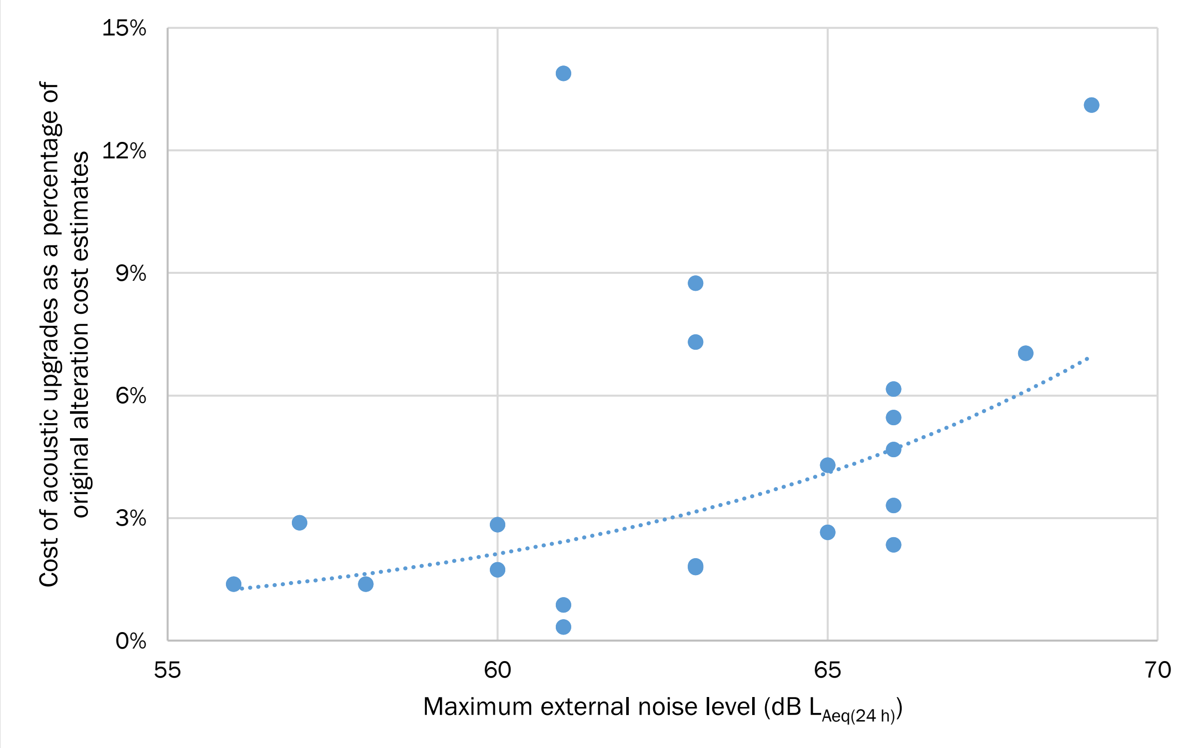

Figure 5.1 – Graph of the proportional cost of acoustic upgrades against predicted external noise levels

One significant outlier not included in figure 5.1 was a project that had a relatively small scope of work, but required extensive upgrades due to the location and nature of the extension. The extension included a large amount of glazing and was in a location that was exposed to a high level of traffic noise. This datapoint has been excluded from figure 5.1 as an outlier, but illustrates that where the scope of the extension is relatively small, the proportional cost of acoustic upgrades could exceed 40% of the original cost of the alteration.

Apart from the significant outlier discussed above, the proportional cost of acoustic upgrades relative to the original project cost was less than 14 percent, as shown above in figure 5.1.

The proportional cost of acoustic upgrades compared to the predicted cost of the original alteration was found to be exponentially proportional to the predicted external traffic noise levels. The trend of the data was found to have the following formula relating predicted external noise levels L in dB $L_{Aeq(24\,h)}$ to the proportional cost of acoustic upgrades C, however there was still significant variation from project to project:

$$C = 0.0000777 \exp(0.132L)$$

This formula has an R^2 value of 0.221, indicating a weak correlation between the external noise level and proportional cost of upgrades.

This is a relatively logical finding, as higher external noise levels are likely to drive more acoustic upgrades – but the scale and arrangement of the project can also play a key role in determining the proportional cost increase overall.

The above finding also implies that the cost of acoustic upgrades to extensions to a dwelling can be reduced by designing the extension to extend away from the road, or to be located in an area that is sheltered from traffic noise.

5.2 Relationship between proportional cost increase and alteration area or the original estimated alteration cost

Despite the sample with the smallest alteration area resulting in a high proportion of acoustic upgrade costs, the remainder of the sample set did not show a clear correlation between alteration area and the percentage increase in cost due to acoustic upgrades. A graph of the percentage increase in cost against the area of an alteration is shown below in figure 5.2. All data points in the sample have been included in the graphs below.

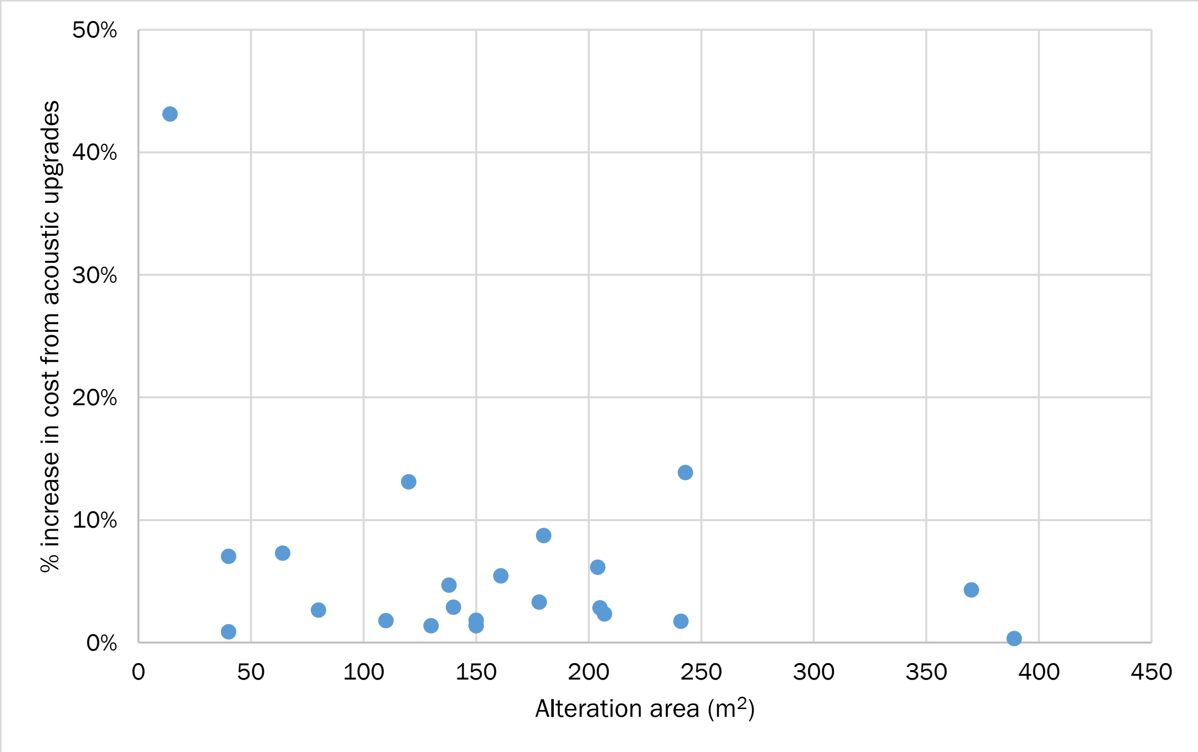

Figure 5.2 – Percentage cost increase of acoustic upgrades against the area of an alteration

This finding is as expected – as a large alteration in a low noise environment, and a small alteration in a high noise environment may result in a similar proportional cost increase. It also follows that as the alteration area becomes smaller, the scatter due to the individual circumstances becomes greater. Due to constraints around the physical layout of most residential sites, only some habitable spaces of a dwelling will be 'close to' the traffic noise source. A project with a large alteration area is therefore increasingly likely to involve more facades which do not require upgrades, as they would face away from the road. A project with a small alteration area may involve facades entirely screened from the road and so require no upgrades, or may only involve facades which are exposed to high levels of traffic noise resulting in a very high proportional cost increase (as was the case with the 'outlier' project above).

The proportional cost of acoustic upgrades relative to the original estimated cost of alterations (NZD Q1 2024) showed a trend where the proportional cost of acoustic upgrades has the potential to be higher where the original estimate was towards the lower end of the spectrum. However a lower cost estimate for an alteration to a dwelling does not necessarily result in a high proportional cost increase. This trend is shown below in figure 5.3.

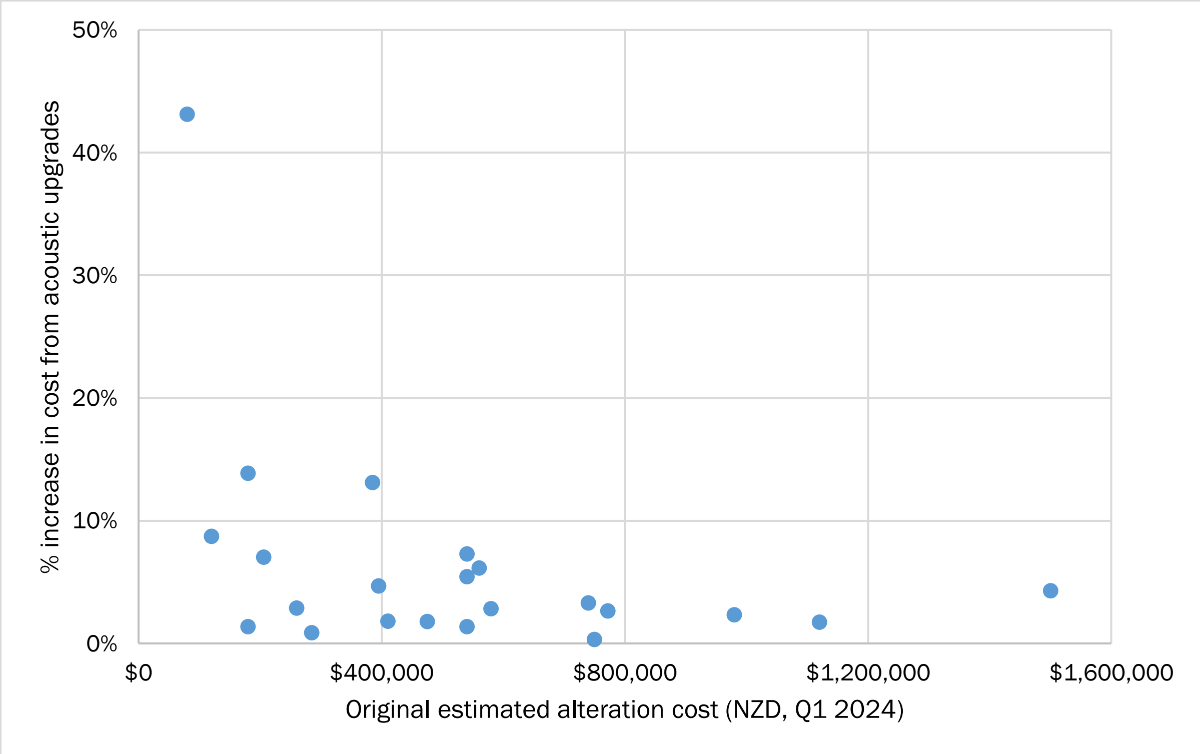

Figure 5.3 – Percentage cost increase of acoustic upgrades against the original estimated alteration cost

Again these observations are as expected, when considering the differing external noise conditions projects are subjected to, along with the potential site layout issues with large vs small projects. (A 'small' project may be entirely subjected to low or high external noise levels, a large project is likely to still only involve one or two habitable spaces being exposed to high external levels, with additional spaces being shielded).

5.3 Absolute costs

Including all data points, the average cost of acoustic upgrades to a dwelling was calculated to be in the order of $21,000, with a standard deviation of $16,000 (NZD, Q1 2024), regardless of the area of an extension.

For the reasons described above (only one or two habitable spaces are able to be located close to the road, for the majority of real residential site arrangements), the absolute cost of acoustic upgrades did not change significantly as the extent of the alteration increased, as shown below in figure 5.4. This results in a higher percentage of the overall cost where the original cost of the alterations is relatively small.

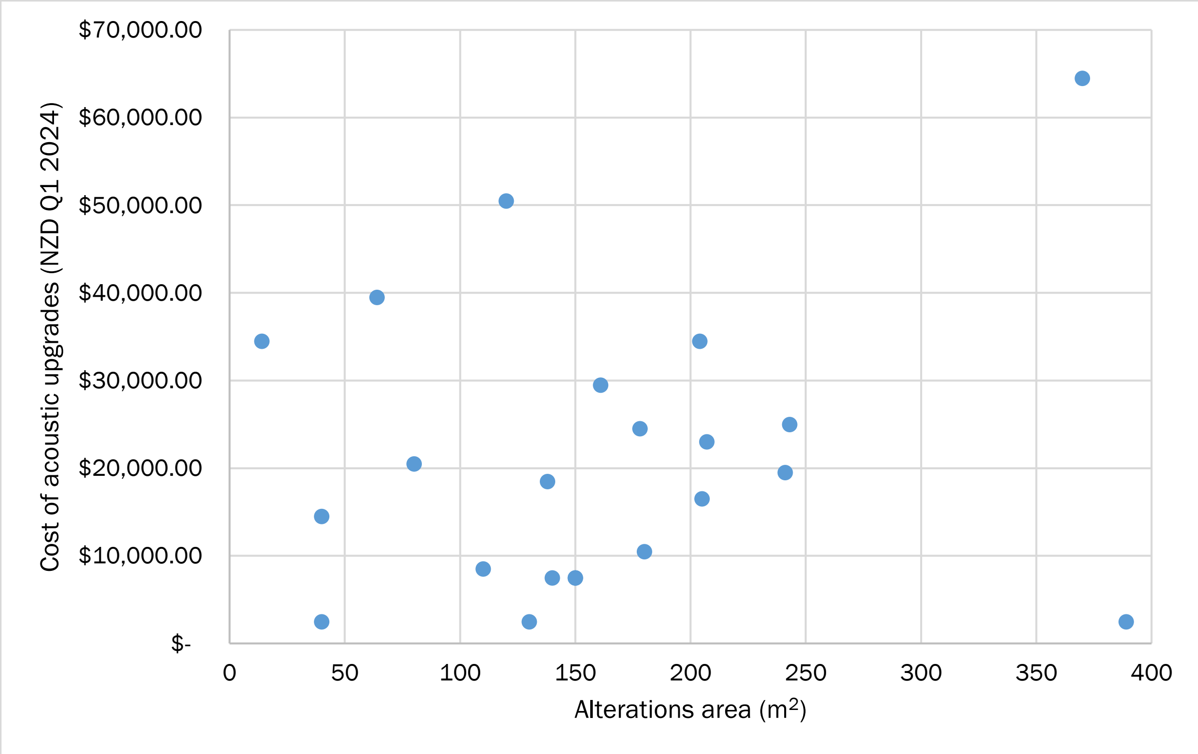

Figure 5.4 – Absolute cost of acoustic upgrades against the area of an alteration

For a small number of developments, no acoustic upgrades were required as either external traffic noise levels were below 57 dB $L_{Aeq(24\ h)}$, or the original design included high mass cladding with small window areas on key facades.

We note that data for alterations of less than 40 m² is limited, with the single data point below 40 m² requiring extensive upgrades. It is expected that smaller alteration areas would typically result in lower than average acoustic upgrade costs, however our sample did not include enough examples of alterations less than 40 m² did not provide a definitive conclusion on this. The trends visible in figure 5.4 may potentially suggest a small alteration (10 – 20 m²) exposed to moderate external traffic noise levels may involve acoustic upgrade costs more in the order of $5,000 - $10,000 (NZD, Q1 2024).

6.0 CONCLUSIONS

We have conducted a study of the cost of acoustic upgrades for dwelling extension and/or alteration projects, subject to a 40 dB $L_{Aeq(24\ h)}$ maximum internal noise level requirement for traffic noise. A sample of 22 real or hypothetical projects were used to understand what general order of financial impact such a requirement may have on owners of residential dwellings that want to extend or alter their dwelling.

The proportional cost of acoustic upgrades for traffic noise was found to increase exponentially with the predicted external traffic noise levels, showing that the cost of acoustic upgrades could be reduced by extending the building away from the road, or to locations sheltered from road noise.

Excluding the outlier described in section 5.0 above, the proportional cost of acoustic upgrades for traffic noise in alterations to existing residential buildings was found to generally be less than 14 percent of the building cost including acoustic upgrades. However, this could be higher where the initial cost estimate for an alteration is low.

The total average cost of acoustic upgrades per project did not change significantly as the size of the alteration increased, and on average was found to cost in the order of NZD $21,000 (Q1, 2024), with a standard deviation of NZD $16,000 (Q1, 2024). Small alterations (10 – 20 m^2) exposed to moderate external traffic noise levels are likely to involve more modest costs than this.

We trust this is of assistance. If you have any queries, please do not hesitate to contact us.

Kind regards,

Jonathan Prins
BE Hons, ME
Acoustic Engineer
Acoustic Engineering Services