Acoustical design of medium-density housing: New Zealand Research Summary

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This article provides an overview of the research project "Acoustical design of medium-density housing", funded by the Building Research Levy.

*The article is based on the summary at the start of the full research report, which is available free on the BRANZ website (*www.branz.co.nz*) as report ER30 (parts A and B).*

1. Introduction

Population growth, demographic change, and environmental considerations, are leading to increasing densification of housing in urban New Zealand. BRANZ, New Zealand's key independent building research organisation, is currently undertaking a research programme to help ensure future medium-density housing (MDH) meets the needs of New Zealanders (for more see www.branz.co.nz/mdh). Previous feedback to BRANZ highlighted noise control as an important consideration for MDH developments.

The collaborative research project "*Acoustical Design of Medium-Density Housing*" was proposed, and funded by the Building Research Levy, to help BRANZ better understand this area and help address the following BRANZ research goal and questions:

BRANZ 2016/2017:Goal and Research Questions as listed for Research Programme 1 / Question 1 of [1]:

"*Providing the building industry with the technical information to design quality, affordable and desirable medium-density housing (MDH) in relation to noise control:*

- *What are the key issues around acoustics and noise control that will need to be addressed to provide for quality, affordable and desirable MDH?*
- *What existing information exists that can support good acoustic performance in MDH?*
- *What gaps are there with this information? Where is there a need for new knowledge? Where is there a need for improved access/uptake of existing information?*"

This summary paper provides a brief overview of the Project and its findings.

2. Research team

To provide a multidisciplinary viewpoint, the core research team included expertise in acoustics, architecture, and engineering from both consultancies and research organisations, specifically: Malcolm Dunn and Tessa Phillips – Marshall Day Acoustics; Prue Fea – Jasmax Architects; David Fullbrook – eCubed; Michael Newcombe – Enovate; Grant Emms and Andrea Stocchero – Scion; Mike Kingan and Brian Mace of the University of Auckland - Acoustic Research Centre, Department of Mechanical Engineering.

3. Research methodology

The Project was broken down into three stages.

Stage 1: Literature review of the current state of play both in New Zealand and overseas, including: information currently available, regulations, and relevant research underway.

Stage 2: Consultation with a broad cross section of building industry participants on perceptions of the key issues, information needs and how to address them. This was achieved primarily through an in-depth building industry online survey "Towards quiet housing" (over 600 respondents), but also through interviews, discussions and practical examples. Participants included those in housing design and construction, as well as those in planning, management, compliance, education and product development / supply.

Stage 3: Analysis of the Stage 1 and 2 findings to provide a comprehensive picture of the key issues and information needs, along with recommendations for solutions that could address them.

The final Project report, completed 30 June 2017 for BRANZ, detailed the full findings from all three stages. The focus was on providing reasonable protection from everyday noise through the design and construction of attached dwellings, rather than the design of planning / zoning requirements.

4. Background concepts

As housing density increases, the possibility of occupants being annoyed by sound related issues increases. This includes potential annoyance due to noise (unwanted sound) from neighbouring activities, as well as a reduced sense of acoustic privacy from increased proximity (including the need to curtail noisier social activities). Noise can come from neighbouring dwellings, other sources in the same building, and the broader environment (e.g. traffic noise and nearby external activities).

Excessive noise levels can significantly affect the health and wellbeing of occupants, as per World Health Organisation research [2], [3],and [4], as well as the amenity of a dwelling. Designing dwellings to provide a reasonable level of acoustic comfort (quietness and privacy) is very important to the long-term desirability of MDH - this was overwhelmingly agreed on during consultation.

The key areas that need consideration in the design of attached dwellings are:

- **Inter-tenancy noise:** reducing transmission of airborne and impact noise (e.g. footfall) from other attached occupancies and from common spaces such as corridors, foyers and internal carparks;
- **Environmental noise:** protection from external noise through the building envelope (including façade, windows/doors, roof, external vents etc.);
- **Building Services noise:** mitigating noise from plumbing, HVAC equipment and other building services (e.g. lifts, mechanical doors).

Acoustical design needs to balance cost against providing reasonable levels of occupant satisfaction without over-engineering or producing difficult-to-build designs.

5. Key findings

The consultation process revealed that the biggest issues centre around knowledge levels across the whole NZ building industry. Key issues identified included:

1. **Needing to raise baseline knowledge across industry:** Although there is a general industry-wide awareness that noise needs to be addressed, there is less awareness about how to address it with failures at any stage in the dwelling's planning/design/construction, having a significant effect on overall outcomes. Feedback indicated this was a big issue.

   This is especially an issue in NZ where residential building has largely focused on detached low-density housing, for which mitigation of noise as part of building design has not been so relevant. Education, training, and ready access to information to help boost base level knowledge across all sectors of the building industry, is therefore a key requirement, especially for those in the residential building industry who are moving from the design/construction of detached housing to attached MDH.

   As an example, even when those involved in a building's design do have a good knowledge of designing for acoustics:

   a) if developers / project managers don't give acoustics sufficient priority or early consideration (or understand the cost benefit) it cannot be well integrated into the whole building design, which is critical for good outcomes. This can lead to acoustics becoming a costly after thought and/or only addressed to low standards;

   b) if installers aren't aware of basic concepts or provided sufficient construction details, simple workmanship errors or substitutions, can significantly reduce the actual performance outcome of any design.

2. **Regulations:** Currently there is a lack of clarity and consistency around NZ acoustic regulations and there is room for additional coverage. However, updates to the New Zealand Building Code (NZBC) to address some of these issues have yet to occur, despite several attempts over the past 15 years.

   Currently residential inter-tenancy noise is addressed through the NZBC Clause G6 (G6) introduced in 1992 with G6 and its supporting compliance document [5] unchanged since 1995. G6 addresses some aspects of airborne and impact noise between abutting occupancies, with interpretation and compliance requirements varying significantly across the country. For example: Auckland Council requires design signoff as well as on-site acoustic testing of a representative sample of completed multi-storey units, whereas other councils may rely on building element design / product specifications.

Protection from environmental noise is provided for in some noisy areas in some NZ district plans, but not in a consistent way. It is managed through a range of different requirements relating to façade performance, internal noise levels to be achieved and ventilation design. Better consistency would be beneficial through inclusion in G6 or as part of new National Planning Standards (part of 2017 amendments to the Resource Management Act).

Industry feedback revealed a wide mix of feelings about existing regulations, though only a tiny proportion felt they were excessive, and many wanted improvement. For example, in relation to G6, the "Towards Quiet Housing" survey question 7 indicated that amongst those with an opinion, less than 2% thought the current minimum performance requirements were too high, and over 55% felt that either additional areas needed to be included and/or minimum performance levels raised.

Even where the regulations were thought satisfactory as a minimum to help address affordability, better support was wanted to help understand the criteria and how to meet and/or exceed them cost effectively. There was also a desire for better understanding of end-user (occupant) needs and what satisfaction levels NZ's current minimum regulations provide.

3. **Lack of readily accessible, NZ specific, independent information:** Although there is a great deal of technical information on acoustical design scattered internationally, there is little independent information on meeting NZ specific requirements, such as local regulations, geographic considerations (climate, seismic), and using the most readily available resources including materials and skillsets. For example, central European based information on heavy weight construction in non-seismic zones with good acoustic performance is readily available. From an acoustic performance point of view this is relevant in a NZ context, but engineers also need to ensure that high mass buildings are designed to withstand seismic movements. Light-weight construction is sometimes preferred for seismic or economic reasons. With less mass to impede noise transfer, lighter weight construction needs extra attention in design and construction detailing to achieve good acoustic performance.

   At present, there is common reliance on a few proprietary NZ product manuals to understand how to meet NZ acoustic requirements. Although these are often appropriate, and are an important link in the design / compliance chain, there was a strong desire for much more access to independent information on general concepts and generic solutions (including a far greater range of "Acceptable Solutions" as part of compliance documentation). It was felt this would help with product comparison, competition and affordability and help practitioners understand the full range of options available, as well as when to seek specialist advice.

   More information was wanted across all areas, but especially inter-tenancy floors, walls and integrated building solutions (see next section). The Project report provides full details on specific technical information needs across all areas, information currently available and gaps in knowledge.

4. **Integration issues:** Currently, acoustic considerations are often not included early enough in the building design process. Given the impact of the whole building design on acoustic outcomes, the best and most cost-effective solutions require good integration of acoustics with structural and fire protection requirements, but also other areas of internal comfort (air quality, temperature and moisture control, natural lighting), sustainability (e.g. energy efficiency) and even aesthetic trends. Feedback noted a lack of integration between the various fields as an issue, with better awareness of the interplay between disciplines needed.

   There was a strong desire for more information on integrated systems and products that can work well together to meet multiple building code requirements. Research which helps develop cost-effective, practical building systems that meet multiple requirements was seen as one of the best ways to reduce costs while providing better quality.

5. **Understanding end-user needs:** The proportion of NZ end-users who live or have lived in MDH has only recently become significant, and the proportion will only increase in future. This means the feedback loop to drive market demand for improved sound insulation performance is only now coming fully in play, including to change developer focus, drive new building product development or inform regulatory requirements.

   In fact, very little NZ-specific, acoustic related, post-occupancy information is available that directly links subjective and objective acoustic performance outcomes. Although overseas experience is useful in the interim, understanding satisfaction rates and performance outcomes with local building techniques, constraints, regulations and end-user expectations is very important, as noted in the recent European COST Action TU0901 study on residential building acoustics [6].

The lack of feedback between end-users and industry participants (as well as between industry sectors) to better understand and improve building systems and regulations, was also noted as a wider industry issue.

6. Recommendations

The Project report gives recommendations for future action, centring on the following key areas.

1. Information dissemination

The first priority is that industry needs much more independent residential acoustic design information readily and freely available as quickly as possible. There is plenty of technical information available, but it needs to be packaged so the most relevant information is easily available to different sectors of industry, in an appropriate format to provide ongoing guidance and support.

Consultation showed that people want up to date, online information from a well-known independent body, providing the latest best practise guidelines and research updates. This should be combined with greater regulatory support through improved compliance documentation e.g. from MBIE (Ministry of Business, Innovation and Employment who are responsible for the NZ Building Code) and councils.

An online "*Quiet Housing Hub*" is suggested as the most effective means of delivering the information, potentially as part of a broader acoustic information hub. This could provide a central reference point for the most relevant information, arranged in a modular fashion with guidance material which can be expanded and updated more quickly and easily than regulatory documents.

Ideally this hub would expand from the general concepts, needed for each topic and industry sector, to include modules with best practise generic constructions (including junction details) that provide good acoustic performance. The UK's "*Robust Details*" system and handbook [7] is also discussed as an example framework. Robust Details was the most commonly referred to useful overseas solution during consultations. Feedback mechanisms, such as comments or forums, could also be incorporated so that the hub can become an integral part of ongoing research.

The hub would be a useful repository both in the absence of immediate regulatory change, and in support of any future changes. The NZBC Clause G6 update process has produced some useful NZ specific documents covering many of the areas highlighted during the Project's consultations. Making the information available for guidance would be extremely valuable, especially as people are wanting more information on generic solutions and achieving above the current code minimum. As the information on the hub would be for guidance only, practitioners would still need to follow compliance processes such as design signoff and/or on-site testing for approval, so there is still a desire for more formal "*Acceptable Solutions*" that assure compliance needs will be met.

Once the hub is created, it is recommended that a promotion and education phase be initiated, to help with raising awareness of the hub and increasing baseline knowledge levels. Once knowledge levels improve, there is potential to use some form of rating system (e.g. star rating) to help inform end-users of acoustic performance outcomes, to help provide transparency and incentivise better quality.

2. Research and development

In response to the industry survey and current state of play, recommendations are made for research areas thought to be most beneficial. In summary, the recommendations include:

- **Undertaking NZ post-occupancy surveys** that combine subjective and objective acoustic performance. Such surveys would provide feedback on the performance of constructions and regulations used in NZ, enabling verification of building design performance and input to regulation. This could be part of broader and ongoing MDH post-occupancy building performance research.
- **Enabling better building designs and solutions**. This includes developing acoustically better systems from existing construction designs and adapting new systems for use in New Zealand. In the case of both proven overseas solutions and local innovations, good information on performance, buildability, local compliance and cost-effectiveness are needed for widespread adoption. Methods and tools are also needed to enable incorporation of performance requirements from other disciplines (e.g. fire, structural), and to make information readily available.
- **Developing better acoustic prediction tools**. This entails adoption and further development of prediction methods which are showing good promise as acoustic prediction tools for sound insulation. Prediction is very important, especially for complex designs (including light weight construction with its multiple connections and components), to help designers understand likely performance.

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massive floor, the increment of performance given by the nib is 3 dB, in presence of lighter slabs the increment can achieve 7 dB.

4. Conclusions

Nine different combinations of floors and walls with a concrete nib at the base have been analyzed using a modified approach of ISO 12354-1 and the results have been compared with onsite testing of the same analyzed constructions. Although only a small set of experimental data was available to completely validate the theoretical model, it appears that the modified approach of the ISO Standard gives relatively accurate correlation between the predicted and field-measured weighted sound reduction index (R'_w) when a nib is introduced at the wall-floor junction.

The introduction of the rigid concrete nib at the base of the lightweight wall appears to change the vibration transmission behaviour through the floor slab by introducing a secondary dissipation path for the sound energy running through the floor. It is interesting to observe how, with some adaption, it is possible to use the ISO 12354-1 methodology to predict the nib effect. The validation of this method could be an interesting improvement of the ISO standard, introducing an additional design tool.

In New Zealand, the use of the nib at the base of the light weight walls is common practice when the floor system appears to have insufficient capability to reduce the flanking transmission, however there is not a developed scientific method to predict how effective the nib may be.

An extension of this experimental campaign is proposed in addition to the work contained in this paper, investigating other similar cases using the same methodology.

A review of the draft of the new ISO 12354 confirms that the prediction approach for this specific application has not changed and the proposed method in this paper will still be valid.

References

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The Project report looks at each of these areas in further detail.

3. Regulations

The industry feedback indicated there is certainly support across all sectors to improve NZ's regulations related to building acoustics. The report urges that efforts actively continue in this direction. In the meantime, it is hoped that the introduction of an information hub would help people become more familiar with what can and cannot be easily achieved and avoid unnecessary mistakes, which should help drive a general improvement in quality. Hopefully, any future shift in regulations will then come more easily.

7. Conclusions

This Project has collated a large amount of information on the current state of play and the most relevant information resources, needs and gaps as they relate to noise control and acoustics in NZ medium-density housing. The extensive industry survey and other consultation includes qualitative and quantitative data covering the full range of perceptions in this topic from across NZ industry.

The suggested online Quiet Housing Hub format should be able to utilize this information to help provide an invaluable expandable resource to deliver technical information to industry, to support better noise control for medium-density housing and any future changes to acoustic regulations. Information from the research areas highlighted can also be better fed back to industry via the hub.

However, building acoustics cannot be considered alone - for quality, affordable, desirable medium-density housing, careful integration is needed with other areas of planning, design and construction.

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