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Medium-density housing technical issues

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Preface

This study is part of BRANZ's medium-density housing (MDH) programme, which aims to inspire the building and construction industry to design, build and deliver quality MDH that meets the needs of New Zealanders. The project's purpose is to both identify and prioritise the technical issues that affect MDH from an industry perspective. Some of these technical issues are barriers to the provision of quality MDH in New Zealand. The study results provide a platform from which to explore solutions to these technical issues.

Acknowledgements

We would like to thank the following supporters and contributors to this study:

- Building Research Levy funding.
- Central government officials from the Ministry of Business, Innovation and Employment.
- 292 building industry representatives who responded to the survey in June 2018.
- 80 building industry representatives who attended six workshops nationwide in September and October 2018.
- Key industry stakeholders who participated in interviews in late 2018 and early 2019.

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Abstract

This report identifies technical issues with medium-density housing as perceived by New Zealand's building and construction industry. The research methods used include an online survey, workshops and in-depth interviews with key industry stakeholders. Stakeholders who participated in the research include builders, designers, quantity surveyors, building officials and project managers. The research findings include the identification and prioritisation of the main technical issues of MDH: fire, pre-build/design, structure, weathertightness and acoustics. Designed as a scoping exercise, this study recommends that solutions for these technical issues are explored in future research.

Keywords

Medium-density housing, MDH, technical issues, quality, fire, noise, acoustics, weathertightness, design, structure.

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Executive summary

This report identifies technical issues with medium-density housing (MDH) as perceived by New Zealand's building and construction industry. Few studies have identified industry perspectives on the specific technical issues facing MDH, and fewer have explored them in the New Zealand context.

New Zealand's housing shortage provides context to this report. As New Zealand's population and appetite for buying housing has increased, in some metropolitan areas space for new detached housing developments has declined. MDH in existing urban areas is prescribed as a solution to continued suburban expansion and at least a partial solution to housing supply and affordability issues. However, its uptake is less than optimal, and market research has identified negative perceptions of MDH developments that act as barriers to its general appeal.

To ensure that MDH remains a viable means to address housing demand and urban sprawl, it is important that technical issues affecting MDH are understood in order to create opportunities for improvement. Such improvements may help ensure that MDH overcomes any negative associations within the housing market.

The research responds to success criteria 1 within the BRANZ MDH research programme, which asks "What are the technical issues that affect MDH from an industry perspective?" By answering this question, the aim of this study is to establish grounds for further research identifying solutions to key issues affecting the production of quality MDH developments.

A mixed-methods approach was employed for this research in the form of an online survey, a series of workshops and interviews with key industry stakeholders. Using these methods, BRANZ researchers canvassed the experiences of a wide range of building industry representatives who have worked on MDH projects. The online survey of 292 respondents produced quantitative data regarding the types of technical issues industry professionals have encountered. This was complemented by qualitative data from six workshops and four key informant interviews that gave insight into some of the themes and issues identified.

Although there was minor variance between data sources regarding some technical issues, there was clear overlap regarding what the research participants considered to be the main issues. The themes of fire, pre-build/design, structure, weathertightness and acoustics appeared most common.

Several prominent examples were evident within these themes, including:

- the potential of façade flame spread
- incorrect use and installation of fire safety products
- the applicability of Building Code clauses to MDH
- water ingress and egress
- the skillset and general capability of all building professionals involved in consenting, design and construction.

Although the research identified some consensus within the industry regarding technical problems affecting MDH, some issues also reflect a strained dynamic between building professionals with strongly differing opinions. This was evident in responses where certain factions within the building industry feel they are not getting the

information they need, or people are not sufficiently skilled to understand the information given.

This difference of opinion shows that, rather than there being a singular perspective on technical issues that beset MDH, there are in fact a variety of industry perspectives. In some cases, these comprise a cycle of blame amongst often frustrated building professionals. This points to the interdependent nature of the building industry where professional groups have their own distinct roles yet also depend on forming effective relationships with other parties for the delivery of MDH to be successful. This raises a challenge for this study and for future MDH research because it suggests that to address technical issues in MDH will (in some cases) require changes to how the building industry operates.

As discussed in the report, this finding connects directly to the intentions of the government's recently announced Construction Sector Accord, which seeks to transform the building industry's culture by promoting more collaborative ways of working.

1. Introduction

This research identifies technical issues that affect MDH from an industry perspective. It addresses a scarcity of available research identifying technical issues encountered in the design and construction of different MDH typologies, particularly within the New Zealand context.

The research responds to success criteria 1 within the BRANZ MDH research programme, which asks "What are the technical issues that affect MDH from an industry perspective?" By answering this question, the aim of this study is to establish grounds for further research identifying solutions to key issues affecting the production of quality MDH developments.

The findings of this research are the result of extensive consultation with industry professionals utilising a mixed-methods approach. An online survey, workshops and key informant interviews were used to obtain insight into industry opinion about technical issues impacting MDH and to identify the most common problems experienced.

The housing shortage in New Zealand's main metropolitan areas provides context to this research. The imbalance between housing supply and demand has led to problems with housing affordability and, in some areas, to a restriction in available land suitable for new housing developments. To address this problem, current strategic urban plans for many New Zealand cities promote consolidation and intensification of activity in existing urban areas. These plans respond to the need to reduce urban sprawl and increase infrastructure efficiency while seeking a more equitable and sustainable urban future (including Auckland's new urban plan). The implementation of these plans requires a shift from traditional low-density, free-standing dwellings to MDH such as terrace houses or apartments.

However, the success of MDH in response to existing housing supply issues is partially contingent on its functionality, which is in turn affected by the quality of its design and construction. In many instances of MDH, poor functionality has resulted in stigma being attached to such developments, which market research shows can be an impediment to uptake. Accordingly, to ensure that MDH meets market expectations, it is vital that technical issues associated with its design and construction are understood.

1.1 Definitions and terms

Internationally, there is no standard definition of MDH, though there is general agreement that attached low-rise dwellings are the principal type of buildings that can be considered MDH (Allen & Bryson, 2018). This project uses the definition of MDH developed in an earlier BRANZ study (Bryson & Allen, 2017): multi-unit dwellings up to 6 storeys high. This earlier study also identified the three major forms or typologies of MDH in New Zealand including:

- 1–2-storey attached houses
- 2–4-storey attached houses
- apartments up to 6 storeys.

For the purposes of this research, technical issues are defined as specialised, practical, applied skills and knowledge used in the building and construction industry to design, build and produce MDH.

2. Description of the research

2.1 Research aims

This research was exploratory and addressed the following key question: What are the technical issues that affect MDH from an industry perspective? The paper details what research participants from within the building industry have told us.

2.2 Methodology

The study involved both primary and secondary research. The collection of empirical data utilised a mixed-methods approach, including an online survey, a series of workshops and a small number of in-depth interviews with key informants. Secondary research involved a review of relevant literature to understand what body of information exists that already identifies technical issues associated with MDH encountered by the building industry. Empirical data was assessed via a thematic analysis whereby responses were grouped according to specific overarching themes that emerged during the research. This enabled the researchers to identify and prioritise a small number of key areas of concern to the building industry within which specific examples were grouped.

Literature review

A literature review was undertaken to confirm that there is a research gap in the identification of technical issues associated with the design and construction of MDH developments. The search terms focused on identifying MDH technical issues as identified by the building industry within both domestic and international contexts. As detailed in section 3 of the report, this resulted in the identification of a small number of articles that detail technical issues from the perspective of both buyers and industry professionals. The review also presents literature suggesting that some technical issues with MDH arise out of broader institutional and procedural issues that beset the building industry. This begins to draw focus beyond looking at technical problems in isolation towards some of the organisational issues that underlie them.

Online survey

The online survey was developed using SurveyMonkey and asked participants to identify the technical issues they had faced or witnessed during the construction of MDH. (See Appendix A for a copy of the survey.) A series of demographic questions were included to allow analysis of the technical issues that were affecting different sectors and levels of the industry. (See Appendix B for a review of the responses.)

The purpose of the survey was to reach industry practitioners with experience relating to MDH development. The survey sample was identified from the BRANZ customer database, which was filtered to include developers, designers, architects, project managers, builders, subtrades, inspectors and property managers. In order to target practitioners with experience in MDH, the database was further filtered to practitioners located in the areas of Auckland, Hamilton, Tauranga, Wellington, Christchurch and Queenstown.[1] These areas were identified as having a higher than average

[1] Note that some respondents indicated that they are based in other regions. This may be due to the BRANZ database having an old address for them or they are living in one region while working in another.

concentration of MDH as identified through analysis of building consents issued in the year to December 2017.

The survey ran for 2 weeks from 11–25 June 2018. The opportunity to enter a draw to win an Apple iPad was offered as an incentive to participate in the survey. A total of 292 participants responded by finishing all of the survey or in part.

Workshops

Following analysis of the survey data, a series of six workshops involving 80 participants were held in Queenstown, Christchurch, Wellington and Auckland to explore survey findings in more detail. (See Appendix C for a review of the responses.)

An invitation to register at the workshops was sent out to the BRANZ database via marketing automation platform Mailchimp. The BRANZ marketing and communications team sent invitations to a wide range of industry representatives (builders, engineers, project managers, building consent authorities, architects and designers) based in Queenstown, Christchurch, Wellington and Auckland. The rationale for this was that most MDH development in New Zealand is concentrated in these cities. Participants were offered a free lunch and a $50 voucher if they attended. The Auckland workshop filled up quickly, necessitating two additional workshops. The workshops each ran for 4 hours (including 30 minutes for lunch).

Key informant interviews

To further validate research findings, researchers for this study conducted four separate semi-structured interviews with key informants within the industry:

- The director of a consultant engineering business.
- An official from Auckland Council who deals with MDH-related issues.
- Two officials from the Ministry of Business, Innovation and Employment (MBIE) with an overview of MDH from a central government perspective.

These stakeholders were chosen because their expertise in MDH provides them each with a broad perspective of technical issues faced by the industry.

2.3 Ethics

This research has ethical approval from BRANZ's external human ethics advisor, in accordance with BRANZ's human ethics policy.

2.4 Disclaimer

This research presents the views of the research participants. The information provided by participants has been analysed and presented in this report. All opinions presented here are the opinions of the research participants.

3. Literature review

A review of the literature resulted in the identification of a limited number of papers of direct relevance to our research question. While a significant body of literature exists on MDH within New Zealand and internationally, few touch upon the technical issues experienced by industry professionals. Instead, much of the literature identified is oriented around issues associated with MDH from the buyers' perspective and organisational and procedural issues that frustrate an industry with numerous stakeholder groups and information pathways.

3.1 Market perspectives

Numerous authors discussing issues with MDH have pointed out the concerns raised by both potential buyers and residents of this property type, and have identified these as reasons why demand for higher-density housing is less than for more traditional detached dwellings.

For example, research has explored the stigma associated with higher-density housing, suggesting it is associated with poor-quality construction and design (Syme, McGregor & Mead, 2005; Vallance, Perkins & Moore, 2005; Arbury, 2005). In some cases, poor-quality construction was blamed for noise transfer issues between units. Tonks (2004: 25), for example, notes that "undesirable levels of neighbourhood noise" is a commonly reported problem in MDH developments, which is often caused by inadequate acoustic insulation, allowing the transmission of noise through floors and between walls.

Previous BRANZ research conducted by Bryson (2017) on attitudes towards MDH validates these perceptions, with feedback from a nationwide survey of New Zealand householders suggesting a widespread perception of MDH as lacking aesthetic appeal, leaky and frequently in need of remediation.

Issues with MDH developments being leaky and with poor acoustic insulation are also evident within international research literature. For instance, Easthope, Randolph and Judd (2015) discuss defects associated with strata developments in New South Wales, Australia with common reports of water leaks associated with issues related to roof coverings and balcony balustrades, and noise issues associated with the poor design of buildings.

3.2 Cycles of blame

Most relevant to the present study is earlier research by BRANZ (Curtis & Brunsdon, 2018) into the defects associated with MDH, a paper by Palmer (2014) investigating the complex social and technical networks related to MDH design in Australia and a study by Dunbar and McDermott (2011) on improving the design and quality of residential intensification in New Zealand.

The BRANZ study involved a construction quality survey into MDH. A property inspection company was contracted to inspect 10 MDH sites during construction and eight completed MDH sites for exterior envelope performance and assessment of ease (or otherwise) of maintenance. Interviews with builders and designers were also undertaken by BRANZ to identify additional issues not raised during the inspections.

The research found a range of problems that commonly face MDH. These included a lack of weathertightness, poor installation of materials and plumbers cutting holes through structural elements to run services (which indicates a lack of integrated design). Interviews established a general perception amongst builders that design professionals were not taking buildability into account during the design of MDH buildings. Some designers maintained that resistance amongst builders to non-standard details owed to a lack of skills to carry out the work on site.

In some cases, the difference in perspective between professional groups can make it challenging to clearly identify where the root of technical problems lies. This is significant if solutions to issues are to be found and agreed to. It leads to a broader analysis of the problems associated with MDH – one that recognises that technical issues sometimes arise within a web of tension between various building professions.

Palmer's 2014 paper explores this topic in the context of MDH in Australia. Addressing issues with MDH, she rejects the tendency of design professionals to objectify the built edifice in isolation from the human interactions that influence how MDH is developed. Palmer argues that to "effectively design and implement change in any given system, an understanding of the complexity of that system and its networks is required" (p. 1). To do this, Palmer advocates for the application of Actor-Network Theory (ANT) to identify which actor(s) hold the greatest power over the final housing outcomes and determine why we have the housing that we do.

Palmer's research into MDH draws focus away from viewing technical issues in isolation to bring attention to how design and construction-related information is formed and exchanged between a network of building professionals and local government officials. According to this analytical model, some technical issues are not necessarily housing or built environment-specific, but a consequence of flaws within existing procedural and communication systems whereby MDH is designed, consented and constructed.

Dunbar and McDermott (2011) reach a similar conclusion upon their study of MDH developments across New Zealand. Drawing on five case studies, Dunbar and McDermott maintain that common problems of MDH being leaky, noisy and poorly constructed can be partially attributed to a lack of coordinated development and trust amongst all key parties – private and public. Without alignment of objectives among different stakeholder groups, Dunbar and McDermott maintain it is unlikely that MDH developments will be achieved in a satisfactory manner. This led the authors to conclude that policy makers should consider alternative institutional frameworks for promoting integrated planning, design and development. This raises a challenge for this study and for future MDH research because it suggests that to address technical issues in MDH will (in some cases) require changes to how the building industry operates.

4. Analysis of survey and workshop data

4.1 Online survey

Five dominant themes emerged during analysis of survey data, as identified in Table 1.

Though discussed as individual categories, there was a degree of overlap across the themes described. For example, technical issues relating to structure have been described as a separate theme. However, many issues relating to fire and acoustics or noise were also related to issues with structure.

Table 1. Frequency of identified themes.

Theme	Mentions
Fire safety	152
Prebuild/design	125
Structure	114
Weathertightness	86
Acoustics/noise	76

In total, 661 technical issues were identified by respondents.[2] Of these, 447 issues were said to have a discernible impact on the design, building and construction process (ranging from a low to severe impact), with the majority being deemed to have a medium impact on the process.

Figures 1–3 analyse the themes identified by each sector, the number of issues raised by sector and the number of issues identified by time spent working with MDH.

Those with more experience working with MDH were more likely to identify multiple issues, and although the survey asked for 'up to' five issues to be identified, those who identified five issues were among the highest bracket (n = 77).

Of those who had encountered an issue, 45% regularly worked with MDH, 37% occasionally worked with MDH and 18% rarely worked with MDH. Of those who have not encountered an issue with MDH, 35% regularly worked with MDH, 26% occasionally worked with MDH and 39% rarely worked with MDH.

As 43.5% of survey participants worked within the architecture, design and planning sectors, the issues raised likely prioritise the issues encountered in these sectors.

[2] Although these five themes were not the only issues identified, they were the most commonly mentioned concerns by participants. Other issues raised included:

- a lack of accidental overflow containment and drainage
- poor handling and planning regarding rubbish and recycling during construction and post-occupancy
- indoor air quality and ventilation
- geotechnical issues.

One respondent also argued that social infrastructure needs to be considered when planning for MDH (such as proximity to schools, medical centres, local shops and so on). These issues, while important, where only briefly identified in this survey, and therefore it is unclear the extent to which they impact on the construction and quality of MDH.

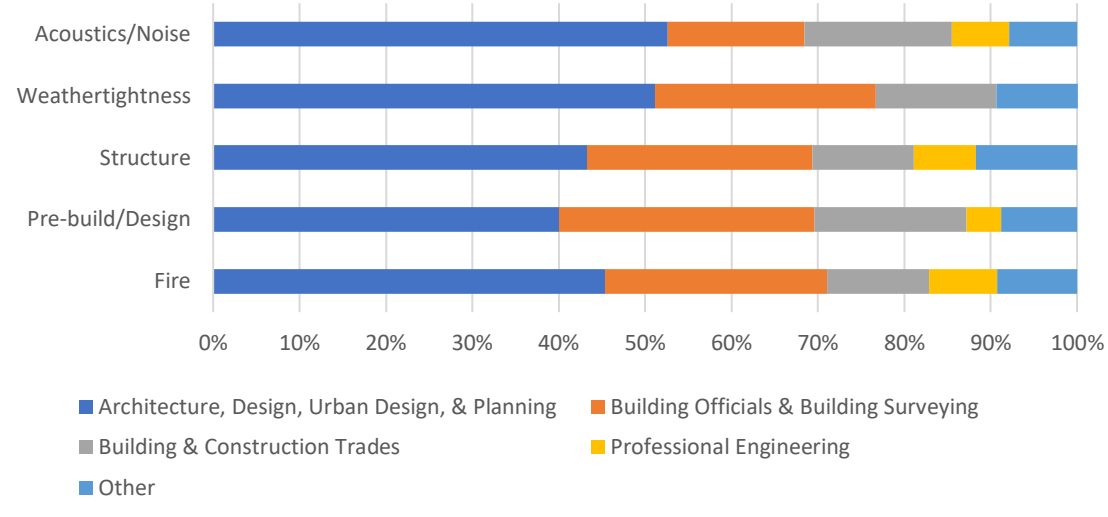

Figure 1. Themes as identified by sectors.

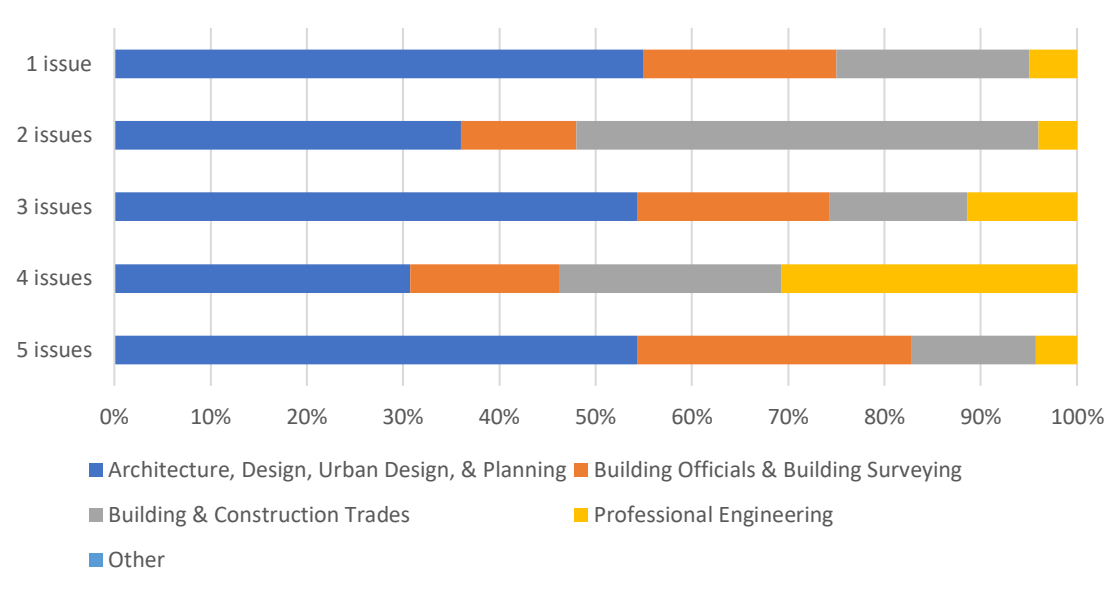

Figure 2. Number of issues raised by industry sector.

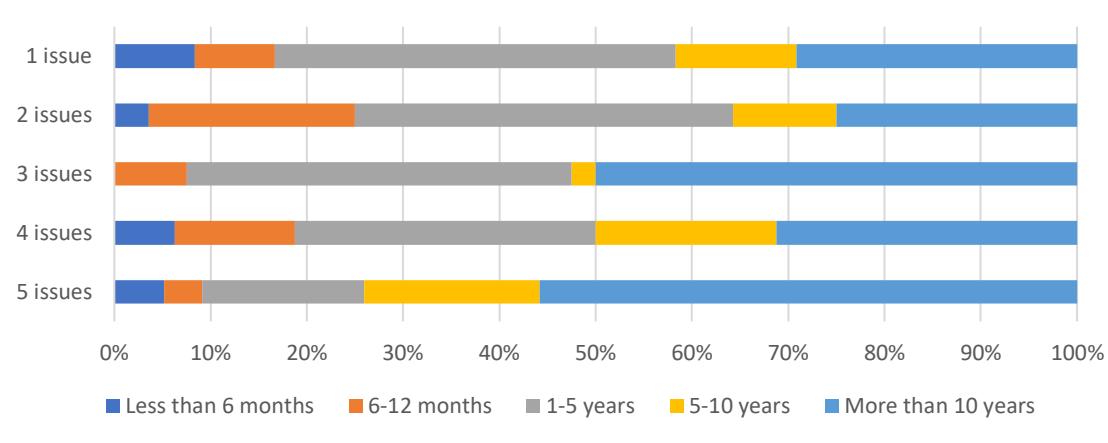

Figure 3. Number of issues identified by time spent working with MDH.

4.2 Workshops

To complement survey data, workshops invited participants to identify, prioritise, then discuss MDH technical issues they experience in their work.

There were a number of commonalities between the survey findings and the information discussed during the workshops, such as the prioritisation of issues with acoustics and fire safety. This is indicative of the common nature of these issues for MDH.

Figure 4 represents the issues identified across the six workshops segmented by topic. It shows that fire and acoustics/noise were the two most commonly discussed issues, raised in each of the six workshops.

This is followed by issues independently relating to materials, services and compliance, which were raised in five out of the six workshops respectively.

Two issues were raised in four workshops – skills/training and transport – and seven issues were mentioned in three workshops – urban planning, education, infrastructure, legislation, ventilation, heating/thermal performance and structure/foundation.

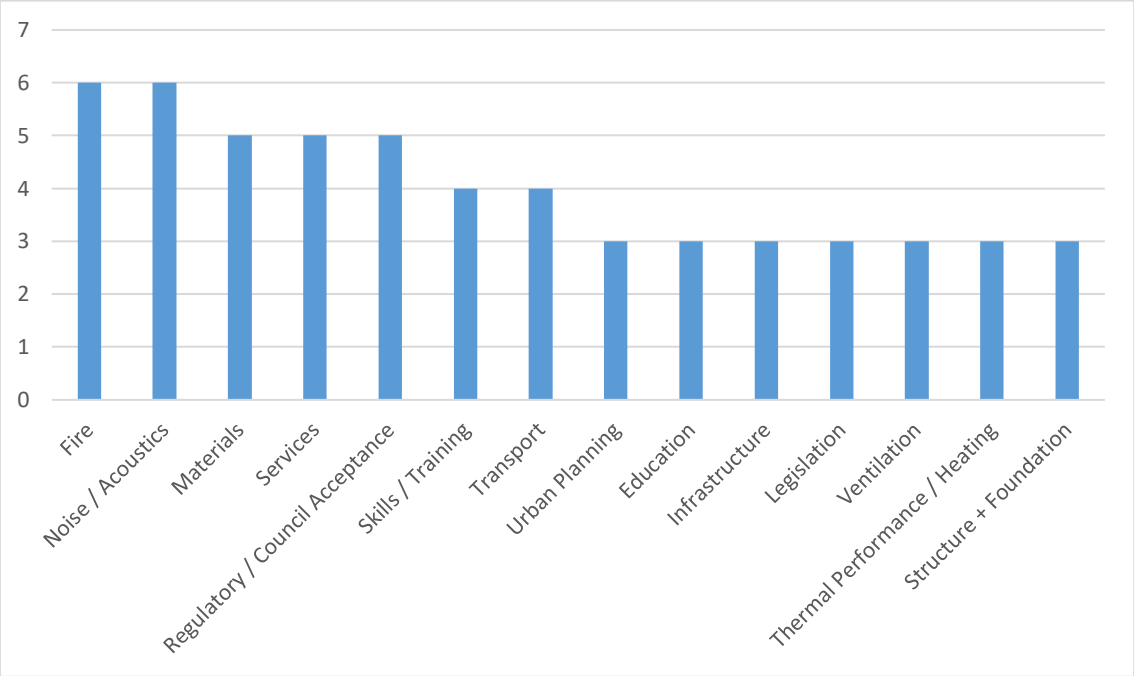

Figure 4. Number of workshops at which each issue was raised.

Figure 5 shows that acoustics/noise was the most prioritised theme in the workshops. However, this was less for the severity of its impact on the building than on the wellbeing of inhabitants.

Understandably, fire safety was also considered a priority issue. This was for the risk to inhabitants as well as for the building itself.

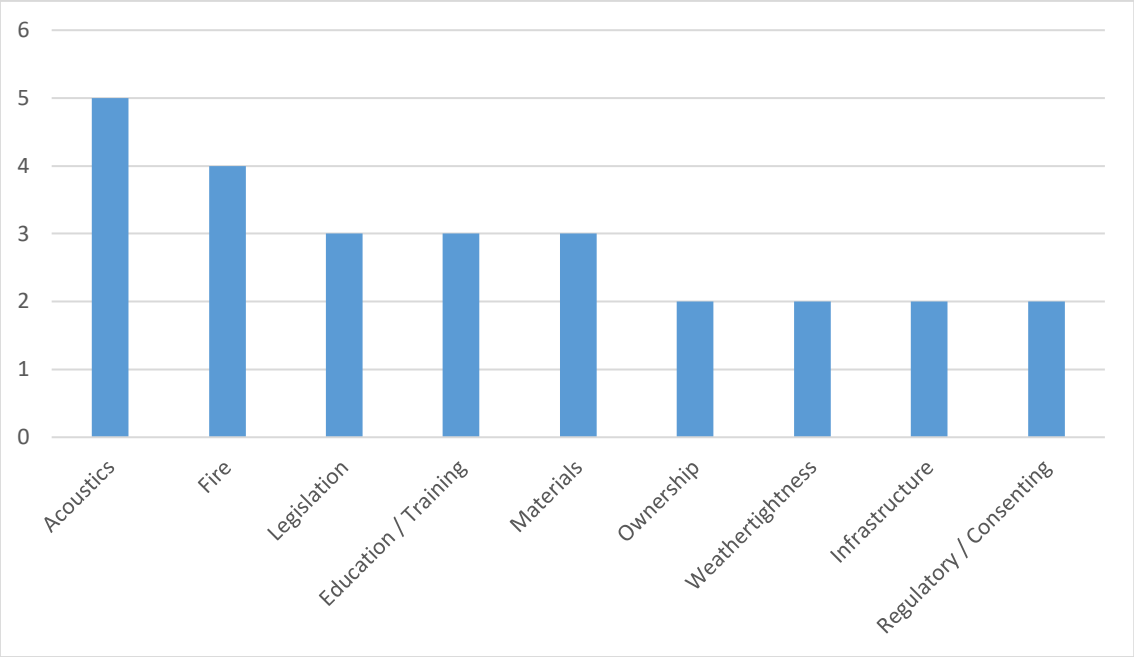

Figure 5. Issues prioritised in workshops (number of workshops in which issues were raised).

Specific comments regarding the main overarching themes taken from both the survey and workshops are discussed below in detail.

4.3 Fire safety

4.3.1 Overview of findings

In total, 152 comments were made in response to the survey regarding technical issues around fire safety. Key areas of concern related to façade flame spread, the incorrect use of fire collars and to more general issues with fire safety in the design of MDH.

Of the 152 issues raised, 45% of these were deemed to have a medium to high impact on the build, while 11% were described as severe. In general, issues with fire safety impacted on completion times and had significant financial implications, and often required serious rework to amend the issues and gain compliance. In some instances (where issues were discovered post-occupancy), occupants were required to evacuate the buildings while rework was completed.

Of the survey respondents who commented on the impact of fire issues:

- 25 respondents classified their issue as having a low impact where there is minimal effort required to fix
- 42 believed their issue has a medium impact
- 26 believed their issue has a high impact
- 17 believed their issue has a severe impact – meaning that there are major risks to inhabitants, the building is uninhabitable and there is significant rework needed.

4.3.2 Façade flame spread

Many issues that were considered to have a high impact on the production and quality of MDH related to the potential of façade flame spread. This was partially attributed to

a perceived lack of quality in available fire-rated timber products. A number of survey participants also noted that the materials available on the market were inadequate, with no suitable alternatives currently available. An Auckland-based building consent manager with over 10 years' experience considered this to be a very serious issue for the future of MDH. He commented that he did not "think the extent of this issue has been fully realised yet".

Cladding was repeatedly raised as a specific example. However, this mainly related to respondents' awareness of international cases where cladding has caused problems rather than direct experience.

The Auckland-based building consent manager raised this in relation to highly publicised fires in London and elsewhere:

> The impact of getting it wrong? Think Grenfell Tower in London or the Lacrosse fire in Melbourne if you prefer closer to home. And there have been a number of façade fires in Asia and the Middle East.

This was repeated by a senior building surveyor from Auckland:

> It is becoming sensitive for cladding compliance, following the burn down of apartment ACP panels overseas. Even though New Zealand has a robust fire design engineer and façade control, the architects are confused due to the mixed reactions by media. It is vital that MBIE and Auckland Council are working closely to develop a clear guidance.

Other responses further demonstrate that the building industry is concerned about the fire risks associated with cladding and is actively seeking government direction on the issue. An Auckland-based building surveyor explained:

> We can't even get a clear definition from MBIE of a cladding system from a fire perspective and the current definition is purely related to weathertightness. Yes, I have been involved in discussions with MBIE to get this, but that was months ago and still nothing.[3]

Although these responses do not indicate that cladding is an active problem for those surveyed, it does show that an awareness of the risk associated with façade flame spread is foremost in the minds of some industry stakeholders.

4.3.3 Fire separations

The seriousness of technical issues relating to fire safety was heavily emphasised. MDH is, by definition, an intensive environment that typically accommodates a large number of occupants. In the event of a fire, this places many individuals at risk. This point was clearly illustrated by an Auckland-based building surveyor:

> People rely on the correct product and installation working to give them time to escape. If they fail to work for whatever reason, people will die. Can't be more severe than that.

[3] Since these comments MBIE has released guidance on the fire performance of external wall cladding systems. See MBIE (19 February, 2019) *Fire performance of external wall cladding systems.* https://www.building.govt.nz/building-code-compliance/c-protection-from-fire/c-clauses-c1-c6/fire-performance-of-external-wall-cladding-systems/

An example given by this respondent was with fire collars being installed incorrectly and the incorrect type of collars being used (such as collars for timber-framed walls being used on concrete floors), which would impact the overall fire design. This respondent viewed that this problem occurred regularly and could have a critical impact in a fire if wrongly implemented.

4.3.4 Design and Building Code compliance

Poor detailing and confusion about compliance requirements were frequently identified by survey respondents and reportedly resulted in significant delays and additional costs. There was a tendency by contractors surveyed to place responsibility on designers to address this. However, it was also noted by some that improved detailing and training across all sectors was considered necessary to address the majority of issues related to fire safety.

Difficulty obtaining compliance regarding fire design was also a problem identified in each of the six workshops. A key issue was that there is a lack of information available that clearly identifies the design requirements. Another issue workshop participants had in this area was in finding these requirements. It was suggested that professionals working in fire design typically needed experience to be able to successfully find the required information.

Other areas of concern highlighted in survey responses and workshops related to a lack of detailing for fire walls, which often cause construction delays until issued are addressed. It was noted that detailing framed walls (for fire walls) is a complex process with MDH. Fire design is conducted by specialists (fire engineers) who some research participants believe focus solely on that design, often with little consideration for other design aspects. While this is an important design aspect to get right, some participants noted that focusing intently on one aspect can lead to issues in other areas that may impact on the overall quality of MDH. Those who raised issues concerning fire walls indicated that this occurred regularly. This relates to the idea that the design and construction processes are too separated and need to be conceptualised as a singular process if the building industry is to achieve quality MDH.

4.4 Prebuild and design

4.4.1 Overview of findings

Issues that occurred prior to construction were listed under the theme of 'prebuild'. The survey elicited a total of 125 comments relating to this theme, encompassing such issues as design, detailing, compliance and the Building Code. Of these issues, 45% were considered by respondents to have had a medium to high impact on the build, with 6% having a severe impact. Only one issue had no impact at all. Although these issues were often considered to be low risk, they were also considered to be highly disruptive and therefore a significant inconvenience.

4.4.2 Design

A lack of clarity in the design was frequently cited in survey responses as a problem impacting the construction of MDH. An Auckland-based project manager with over 10 years' experience with MDH noted the importance of detailing, stating that "the higher the density, the more critical good detailing becomes".

Some survey participants involved in construction felt that designers were creating overly complicated designs and many respondents in this sector questioned their buildability. There was also a perception amongst contractors that design professionals lack an understanding of how to design key features of MDH such as firewalls, cladding, acoustics and joinery. Several participants felt that this may be related to designers having difficulty in interpreting Building Code requirements, particularly clause C *Protection from fire*.

Conversely, although some design professionals agreed there were issues with compliance, it was commonly understood this was less to do with the quality of their design than council-imposed barriers. Councils were thought to be putting up significant and unnecessary hurdles that slow the compliance process, waste time and add costs. Additionally, there was a general perception amongst designers that some tradespeople lack the knowledge and skills required to understand plans and implement MDH-specific design elements.

When asked what needs to be done to address these issues, survey participants strongly advocated for more effective and specific training for designing and building MDH. Participants suggested that training should be ongoing – with suggestions for the development of MDH-specific courses to continue educating workers throughout their careers. As the workshop participants predominantly came from the design sector, the types of training suggested in this part of our study reflected this. There was discussion about the need for better or more effective training at the university or polytech level. It was noted that a large number of Bachelor of Architecture students do not get taught detailing to an effective level.

There was also the suggestion within the workshops that contractors should have greater training requirements. Examples included certain requisite qualifications or that a certain number of tradespeople on site should be required to have specific qualifications. In line with this, it was suggested builders have speciality qualifications for MDH in areas such as cladding, roofing and so on.

Rather than reflecting industry consensus about technical issues associated with MDH design, these responses indicate that there is a degree of finger-pointing and frustration with other building professions within the building industry. This cycle of blame may reflect that some technical issues are caused by communication problems amongst professional groups.

4.5 Structure

4.5.1 Overview of findings

As noted, there is a reasonable degree of overlap between structural issues and other themes discussed, including noise, pre-build and fire issues. However, a significant number of comments were made regarding structural issues, and therefore it has been included as an independent theme. In total, 114 issues were raised related to structural concerns. These included issues with walls, joinery, bracing, stability, wind and the building envelope. The majority of these issues were classed as having medium to high impacts (50%), with 7% having a severe impact. Only two issues were said to have had no impact.

4.5.2 Wall bracing

Issues with wall bracing, particularly on lower levels, were frequently raised. A structural engineer from Canterbury noted that it may help to resolve this issue by placing bedrooms on the lower levels and having living areas on the higher levels. This, he stated, would provide more bracing in the lower levels as opposed to having wide open spaces. It was also noted that addressing other concerns with MDH – such as fireproofing or weathertightness – may require the use of heavy materials (for example, concrete blocks), which likely increased the structural demands.

4.5.3 Wind loads

A construction manager from Auckland noted that there was a lack of understanding regarding the structural impact of wind loads. This particularly impacts on the façade and cladding, where cladding may peel off due to heavy wind impact. Further impacts can come from water leakage seeping through gaps created by wind.

4.5.4 Seismic resilience

There was also concern about the impacts of seismic movement. One Wellington-based architect noting that serviceability limit state (SLS) and ultimate limit state (ULS) movements on façades, interior fire rating resistance and acoustic partitions presented the most high-impact and frequently occurring issue with MDH in his experience. To manage this issue, he suggested that new products and system testing was needed, particularly as New Zealand is a country frequented by seismic events.

4.5.5 Compliance with NZS 3604:2011

According to survey and workshop participants, one of the major issues is the difficulty in transferring Building Code clauses to MDH. In particular, this relates to vertical MDH where the clauses may not be applicable to buildings over a certain height. NZS 3604:2011 *Timber-framed buildings* is applicable for low-rise structures. However, an Auckland structural engineer pointed out in his survey response that it is not a reasonable solution for some MDH typologies as it only applies to buildings up to 3 storeys. Some respondents suggested that revision of this standard was required or that a new standard specifically addressing or dedicated to vertical MDH in excess of 3 storeys was needed moving forward.

4.6 Weathertightness

4.6.1 Overview of findings

Issues in achieving weathertightness were raised in both survey and workshop responses. Because there are typically a large number of junctions within the claddings of MDH, there are many issues to address and much room for error. Accordingly, it is unsurprising that a total of 86 comments were made by survey respondents regarding weatherproofing, water and moisture. These were grouped together under the theme of weathertightness, which includes Building Code clauses E2 *External moisture* and E3 *Internal moisture*.

Water ingress was mentioned repeatedly by survey respondents, and there was significant cross-over with issues that arise from external aspects of a building. Commonly identified features included cladding, flashing, façade treatment and decking or balconies. This was a significant concern across New Zealand for study

participants. Almost half of the weathertightness comments (39 of the 86) related to cladding and façade issues.

Of the 86 comments, 44% were deemed to have had a medium to high impact on the build, while 13% had a severe impact. Only two issues were said to have no impact. Those within the design sector raised 51% of issues relating to weathertightness, with 26% coming from building officials and surveyors, and 14% from those working in building and construction.

4.6.2 Cladding

Problems with cladding were heavily emphasised in the survey and appear to be a serious and commonly occurring issue with MDH. Survey participants noted that there is a persistent issue with the availability of effective and tested cladding systems. Where issues occur, these impact on a number of areas, including façade selection, watertightness, economics and aesthetics. The costs of effective cladding systems can be high, which may deter the purchase of quality materials and systems, and their competent installation. Certain materials and systems will also require more maintenance than others, leading to an increase in long-term costs. Where issues occur, remediation can consume a significant amount of time, particularly where further detailing from manufacturers is required.

Citing issues with weathertightness, many survey respondents specifically mentioned issues with cladding junctions caused both by poor design and installation. It was suggested that requirements for cladding and façades needed to be clarified to ensure that these components did not contribute to or cause issues.

Several participants perceived designs to be too complex. One construction project manager from Hawke's Bay argued that designers needed to "simplify their designs and provide absolutely clear details on how to achieve weathertightness". This notion also extended to manufacturers, who the same respondent felt needed to "ensure that their details are clear and that the installer has the latest details".

Workshop participants reinforced that there are widespread industry concerns with cladding, with some noting a lack of information available on the varied junctions for MDH. This was noted as a problem for junctions between different types of cladding material. It was suggested that some designers are not exhibiting competence when specifying a cladding material when designing new MDH developments.

4.6.3 External water ingress

External water leakage in general was a serious concern and, in the view of some survey respondents, contributed to the deterioration of external building elements. Balconies were identified as a common source of leaks, with poor waterproofing of the deck and balustrade reportedly creating regular issues. Where waterproofing was inadequate, some respondents experienced that water would leak through balconies into units below, causing timber to rot and requiring significant repairs.

Attached housing can face different issues to stand-alone homes, and the junctions between houses were the source of many weathertightness issues. Roofing junctions in terraced housing created serious concerns. A CAD technician and an architect from different parts of the country separately noted in their respective survey responses that MDH roofing structures were at highest risk when there were different ground levels of adjacent units. Issues with roofing were said to occur frequently and often had a

moderate impact on the building process, requiring design alterations and resulting in additional costs.

4.6.4 Compliance

E2 *External moisture*

Issues around Building Code compliance relating to weathertightness and moisture were repeatedly raised by participants in this study. A major point of concern amongst survey participants related to a lack of clarity within the Building Code, particularly Acceptable Solution E2/AS1 and the applicability of Building Code clauses to MDH. E2/AS1 only applies to buildings up to 10 metres in height, and there are no clear guidelines for buildings outside of this range.[4]

One central government official participating in the survey noted:

> MDH buildings effectively fall into a gap between small buildings (those that can use ready-made solutions like E2/AS1) and larger buildings which can commercially justify specialist consultants like façade engineers.

This limitation was continually mentioned across the study and appears to have a significant impact on the building process, creating difficulties during the consenting process and often resulting in additional costs.

E3 *Internal moisture*

Concerns about compliance also extended to clause E3 *Internal moisture*, especially relating to free water overflow from one residential unit to the next. A building surveyor from Auckland stated:

> E3 and in particular E3.3.2 of the code and how to deal, or not as the case may be, with accidental overflow and protection of household units and other property… The impact of a flow restrictor failing, and they will as will any mechanical device, is major…. Designers appear to be unaware of this issue or argue persistently to get around it.

For other respondents, concern about internal moisture extended to councils' own grasp of clause E3. A senior architect based in the Bay of Plenty explained:

> Council also, while having a very good comprehension of E2, seem to be missing large portions of understanding from E3. This means that significant extra cost is incurred by the client as constant oversight and paperwork is required.

Technical specifications and contractor skillset

Amongst contractors participating in the workshops, concerns about compliance extended to issues related to a lack of technical specifications being supplied by designers. Specifically, disparity was identified between resource consent and building consent information, particularly where designers had not worked out technical construction details during the resource consent stage. Some workshop participants

[4] However, BRANZ has produced guidance on this issue in BRANZ (2019). *Performance of mid-rise cladding systems* (version 2, May 2019). BRANZ Evaluation Method EM7. Judgeford, New Zealand: BRANZ Ltd.

Reference to EM7 in the Building Code as a Verification Method is expected by July, 2019.

noted that this becomes a serious issue when applying for building consent and councils ask for more specific information.

This frustration extended to manufacturers who only provide generic details for their products and systems. When applying for consent, some workshop participants reported that councils would often ask for more specific information to be supplied by the manufacturer, slowing down the consent process. One Auckland-based building surveyor suggested that manufacturers should be required to provide more specific details about their products:

> [M]anufacturers and suppliers [need to be] more responsible, not just the "we only supply the product" mentality. Again, it's about taking a holistic view of things, not just a narrow view.

Conversely, a view amongst design professionals at some workshops is that contractors are typically too unskilled to adequately deliver MDH. While this was identified as a problem for MDH as a whole, it was also specifically identified as a problem in relation to weathertightness. For some workshop participants, upskilling the current workforce by providing specific MDH training for all involved in the development and construction of MDH would greatly help to address some of these issues. It was also suggested that design consultants should conduct more site visits and have discussions with contractors working on site.

4.7 Acoustics and noise

4.7.1 Overview of findings

Noise was a prominent theme in this study. A total of 76 survey comments were made about noise-related issues with MDH. This theme included any comments regarding noise, sound and acoustics. Of the identified issues, only one issue was deemed to have had a severe impact on the build (impact noise from above apartments), 42% had a medium to high impact and 17% had a low impact. Participants noted that acoustic concerns were comparatively low risk, impacting on the overall quality of living and wellbeing of inhabitants rather than posing physical risks.

4.7.2 Noise transfer

Understandably, given the higher density of living in MDH developments, the key concern amongst survey participants regarding acoustics was the inability to prohibit noise transfer between party walls as well as vertical sound transfer in multi-storey developments. Multi-level timber floors were seen as a key contributor to noise transfer, and some comments specified that a key problem lay with the timber floor products being used. Some respondents noted that this problem was making it hard for MDH developments to comply with Building Code clause G6 *Airborne and impact sound*.

Sometimes this problem was seen to arise from contractors' inability to follow suppliers' specifications. An Otago-based architect with more than 10 years' experience stated:

> [There is a] risk of not following supplier's 'system' to the letter. Risk of variance between acoustic engineer spec and what is constructed on site. This also relates to acoustic versus fire rating requirements of inter-tenancy walls.

Another concern highlighted by survey respondents related to noise from building services. According to an Auckland-based building consent officer, noisy plumbing and other services appear to be a key cause of noise complaints because plumbing and venting configuration allowed sound to transfer between units. Pipes running through the mid-floor were also seen to affect noise resistance, and it was noted that noisy plumbing is not adequately addressed in Acceptable Solutions.

Survey respondents further noted that noise-related issues resulted in additional costs and delays, particularly when remedial work was needed to address concerns. The experience of some contractors was that certain elements of MDH often need to be altered to meet acoustic requirements such as the depths of mid-floors and sizes of walls. In some instances, redesigns were required to remedy acoustic issues – such as when an architect from Waikato had to redesign the mid-floor to be set down to allow for acoustic intermediary layer. It was difficult to make alterations needed where acoustic components were inadequate, particularly once consent was approved.

Respondents noted that they were typically unable to guarantee acoustic performance to a satisfactory level, with testing often providing inconclusive results. This resulted in increased uncertainty of the construction being fit for purpose at completion and handover.

Some workshop participants also noted that it is difficult to find cost-effective ways to design out noise, particularly when addressing impact noise from above apartments. Tight spatial designs made it difficult to effectively install acoustic systems between units, both vertically and horizontally. Attempting to address sound transfer across units can lead to the use of heavy materials (such as concrete) consequently affecting the overall cost and structure of the building. Balancing design, functionality and cost seemed to be a pressing issue in this respect, with one Nelson-based architectural designer noting:

> Constructing a detail that works structurally, acoustically, and for fire often ends up being … expensive.

Several workshop respondents noted that the introduction of better lightweight systems would be beneficial in addressing sound transfer. In addition to higher costs, some participants also said that effective solutions to acoustic issues can extend build times, which can be viewed negatively by clients. A commonly cited measure to address this was to improve details in the design stage and to develop materials that could conform to both noise and fire ratings.

4.8 Discussion

Analysis of survey and workshop data suggests the building industry experiences a wide range of technical problems in the design and construction of MDH, many of which are largely consistent with the literature.

Although there was some variance between data sources regarding technical issues identified, there was correlation between survey and workshop participants on several issues. Fire safety and noise transfer were clearly identified as priority concerns. Specific examples include:

- concerns about the quality of fire-rated products
- the improper installation of fire safety products
- the transfer of noise between dwellings and from external sources.

However, it is notable that problems associated with MDH design and Building Code compliance permeated responses across most themes.

While there was widespread consensus amongst study participants regarding many technical issues, there was disagreement between sectors within the building industry regarding the nature of some of these problems and who is responsible for them. This was particularly clear with evidence of frustration between designers and contractors. On numerous occasions, they pointed to each other for providing insufficient detail in the design and specifications or for lacking the skills necessary to understand design and to build to its blueprint. For example, design professionals felt contractors were not installing cladding or acoustic materials correctly, and contractors felt design professionals were providing insufficient detailing for fire walls or overly complex designs for cladding.

Statements regarding contractors' annoyance with manufacturers providing a lack of detailed product specification suggest that the frustration between professional groups is not limited to design professionals and builders alone. This is significant for this study as it suggests that accompanying the identification of some technical problems facing MDH is a cycle of blame where certain factions within the building industry feel that they are not getting the information they need, or people are not sufficiently skilled to understand the information given.

It is likely that many of the technical issues identified are part of a broader problem associated with planning and coordination between building professions. This was not only evident in the schism between designers, builders and manufacturers, but in responses that identified that better guidance was needed from central and local government. An example is the fire rating of cladding products.

This indicates a lack of coordination amongst the different groups involved in the entire process of producing MDH. Some survey comments specifically referenced this, with one building surveyor from Auckland stating:

> [We need to] assess the proposal as a whole, not a series of individual components put together on a hope and a prayer. NO one takes overall responsibility.

This frustration was also captured by a building inspector from Wellington:

> Every aspect of the job has issues from the foundation to the fire rating. It also makes those involved with the job want to drive a 6-inch nail into my head.

Beyond the need for better planning and coordination, there was a broad consensus within the survey data that a range of changes are needed to address the technical issues affecting MDH. When asked what needs to change to resolve these issues, responses were relatively evenly spread across 'improved detailing' (25%) and 'training' (26%). A reasonable number of participants also identified 'building code clause revision or new standard' as an important area to address (17%). The majority of respondents who answered this question selected 'other' (32%) and identified more specific solutions. Many participants indicated that it was a combination of all of these that needed to be improved. It was also suggested that greater monitoring and supervision would be beneficial.

5. Key stakeholder interviews

To further test our findings, researchers conducted four key informant interviews with industry stakeholders, each with substantial MDH experience. This involved separate semi-structured interviews with:

- a director of an engineering consultancy
- an Auckland-based council building inspector
- two building and construction officials from MBIE.

These interviewees were selected for their experience and broad understanding of MDH issues relating to their respective roles. During the interviews, each stakeholder was asked the open-ended question: "Based on your professional expertise, what do you think are the most pressing technical issue or issues within the construction of medium-density housing?" Participants were also asked to give examples where possible and rank these issues according to their severity and frequency.

5.1 Fire safety

In line with survey and workshop responses, issues around fire safety emerged as a prominent concern during key informant interviews. This was detailed by the council building inspector who explained that:

- 10–15% of pre-line inspections fail on fire grounds, with common failures being around backblocking walls and electrical flush boxes
- 70–90% of post-line inspections fail on passive fire grounds.

The incorrect use and installation of fire collars was also listed as a concern. This interviewee considered fire issues to be of moderate severity but of high frequency.

Similar concerns were shared by the engineering consultant. However, rather than placing the blame on contractors, this interviewee felt that the practicality of fire design is often overlooked owing to a lack of technical ability amongst council officials when assessing specialised components. This person felt that this contributes towards a perception of poor fire safety in MDH, especially in developments that lack ongoing maintenance of critical safety components as buildings age.

The two MBIE officials interviewed disagreed that a lack of technical ability amongst BCAs is a problem. They pointed instead to a skill shortage within New Zealand's building and construction industries manifesting in a shortage of skilled fire engineers. Accordingly, they agreed that one of the main issues with fire design in MDH is that the quality of such designs varies. They felt this issue is compounded by a lack of rigour in fire engineering compared to other engineering disciplines, creating a disconnect between the standards set in fire regulation and what happens at the industry's coalface. This was judged by one of the MBIE interviewees as a technical issue of high frequency and severity.

One MBIE official also stated a belief that the fire rating of materials is often undermined by contractors making multiple penetrations through fire-rated products to run services. In this official's view, such poor-quality work by contractors threatens to undermine the performance of MDH during a fire emergency. When asked to assess this issue, the official explained that, although such issues occur with moderate frequency, the impact on MDH buildings and residents could be severe.

Concerns about how information is shared and understood amongst building professionals also arose in discussions. The council building inspector noted a frequent disconnect between fire and structural engineers around issues such as post-fire stability and between fire and façade consultants around the performance of cladding. The building inspector explained that there is a need for ownership of quality assurance around some aspects of fire design, and central government guidance around who is responsible for this would help.

Echoing this, one MBIE official explained that the Building Code often creates confusion between design consultants because Building Code requirements for structure, fire, acoustics and weathertightness are laid out separately. To manage this, the official explained that the Building Code needs updating to include solutions that comply with multiple Code clauses.

However, the second MBIE official felt that some designers struggle to come up with a detail that meets different compliance criteria. This interviewee suggested that this is because they are not taught how to do this and must learn such detailing over time. The official accordingly felt that designers must take a more holistic approach to their work, ensuring that their design address compliance with all aspects of the Building Code while ensuring that it can be easily constructed.

5.2 Structural issues

Structural issues associated with MDH stood out during key informant interviews, with the council inspector, the engineering consultant and one MBIE representative all rating structural issues of high severity and frequency. The building inspector noted that imported steel is presenting issues on many sites. In most cases, councils are not able to verify details around where the steel was manufactured, its chemical composition and who applied the intumescent coating. In the inspector's view, this has resulted in construction for some MDH developments being stopped owing to poor compliance and documentation around their steel products or for impurities in steel that did not match its product specification.

Like fire design, the engineering consultant felt that MDH structures were increasing in complexity and were becoming beyond the ability of consenting officers to assess. The consultant felt this meant that some projects lack effective BCA oversight of design or construction. Accordingly, this interviewee believed that BCAs were increasingly relying on producer statements from the design engineer and peer reviews to provide a check and balance.

The engineering consultant also stated that an underlying cause of some structural issues is that design teams are often pressured to compromise on the quality of their structural design to meet clients' expectations around cost and aesthetic result. They maintained that this issue was compounded by project managers in design-build projects often lacking the skills and experience to lead the design process while nevertheless being responsible for project risk and cost. To ensure that poor design is properly identified and assessed, this interviewee suggested that engineers spend more time with consenting officers during the consent stage.

One MBIE official agreed that the quality of structural design varies significantly - attributing this to a shortage of skilled structural engineers and some smaller engineering consultancies not including quality assurance into the cost of their design. The official stated that this was particularly a problem when graduate engineers are

doing much of the design work without enough oversight from structural engineers with greater seniority and experience.

According to the same MBIE official, equally concerning is that some developers are not completing enough geotechnical testing prior to the build. When asked to elaborate, the official stated that, although geotechnical testing is often completed for resource consent, some developers fail to complete further testing, which in some cases leads to MDH developments proceeding without sufficient information about ground quality.

5.3 Design, acoustics and weathertightness

Like survey and workshop responses, issues relating to MDH design during interviews were broad and were threaded through many different topics. As an example, design was frequently raised by interviewees in relation to building acoustics. The council building inspector noted that inexperienced designers typically follow GIB acoustic guides, which neglect aspects like the impact of penetrations for services and baths against inter-tenancy walls. Accordingly, the inspector explained that the highest growth in complaints to council is about inter-tenancy noise. To address this, this interviewee maintained that clause G6 should be updated with sound transmission and impact classes raised by a minimum of 5 points, which designers would then treat as the bare minimum.

Technical issues relating to noise (both from other tenants and from the street) were also rated by the engineering consultant as a frequently occurring problem but with minimal overall impact or severity (other than on tenants' lived experience). Specifically, the consultant maintained that many acoustic issues primarily relate to the industry's general focus on achieving the absolute minimum in terms of design (for example, complying with GIB noise product guidelines) and its neglect of MDH dwellings' overall acoustic performance. Accordingly, this interviewee felt that more attention to acoustic design and the measurement of acoustic performance was required within the industry to avoid negative perceptions of MDH.

Discussing weathertightness, one MBIE official felt that there was complexity in some façade designs that is not easy for builders to cater to. As an example, the official explained that some MDH designs call for a combination of different façade systems that require multiple installers, and some installers are not required to coordinate or understand how these systems interface. Although the different systems may have been independently tested for compliance, when used together in MDH construction, a lack of installation coordination increases the risk of failure. This is especially so, the official explained, in higher-level MDH where façade systems are more difficult to access and maintain. The official further explained that addressing this problem requires better education for designers and system suppliers around how to manage the interface between different façade systems. It also requires more detailed installation specifications for tradespeople to give direction on how different systems should be installed to ensure weathertightness.

5.4 Discussion

Feedback from interviewees suggests that these stakeholders' concerns are consistent with the main themes raised in both the online survey and workshops. Issues raised regarding fire safety, structure, acoustics and weathertightness appeared at most to be variants of the same concerns raised by survey and workshop participants. For instance, disquiet about the lack of technical ability amongst council officials to fully

understand and assess fire and structural design mirrors similar concerns with BCAs raised elsewhere in the study. This is especially around the inability of councils to grasp the design implications of Building Code clause E3 *Internal moisture*. This reflects a lack of faith in the institutions set up to ensure MDH structures comply with Building Code performance criteria.

Comments on the disconnect between fire and structural engineers regarding issues (and between aspects of the Building Code itself) echo sentiments from survey and workshop participants that there is a lack of integrated design and a lack of guidance from central government regarding solutions that comply to all aspects of the Building Code. This reinforces the view that MDH design disciplines are too separated and need to be conceived as a singular (yet multi-faceted) process to avoid similar conflicts.

Structural issues were more strongly emphasised by interviewees than survey and workshop respondents. Problems associated with the chemical composition of imported steel and the lack of geotechnical investigations had not been raised before, and this presents a different dimension to the structure theme. However, it is possible that this is linked to the concern that clients' expectations around cost drives down design and construction quality.

Noise transfer and issues around water passing through the building envelope owing to the junctions between façade systems again reflect similar statements made by survey respondents and workshop participants. This reinforces the view that these are common issues for MDH experienced by building professionals throughout the country.

6. Conclusion

6.1 Overview of findings

This report identified technical issues with MDH as perceived by New Zealand's building and construction industry. By identifying technical MDH issues faced by industry professionals, the goal of the study was to establish a platform for further research identifying solutions to common problems affecting MDH developments. This is important because prior research has indicated that poor MDH design and construction has resulted in stigma being attached to such developments, impeding their uptake when they present a potential solution to restricted land supply in urban areas.

The findings of this research were the outcome of consultation with over 370 industry representatives utilising both qualitative and quantitative research methods. Although the quantity of issues identified by research participants was broad and the issues wide-ranging, correlation between survey, workshop and interview participants was evident on several issues. These can be broadly grouped into the themes of fire, structure, pre-build/design, weathertightness and acoustics.

Several prominent examples were evident within these themes, including:

- the potential of façade flame spread
- incorrect use and installation of fire safety products (for example, fire collars)
- applicability of Building Code clauses to MDH
- water ingress and egress
- noise transfer
- the skillset and general capability of all building professionals involved in consenting, design and construction.

Technical issues relating to fire safety consistently rated high across each information source, and this theme stands out from others in terms of priority. Although issues with building acoustics also rated highly, it is important to note that this corresponded more to the impact on the lived experience of MDH residents.

While there was widespread consensus amongst study participants on a number of issues, it also appeared that, in some cases, there are deeper issues that underlie them. This was most evident with the cycle of blame between designers and builders who frequently pointed at each other for lacking consideration for the buildability of their design or for lacking the skills necessary to understand design and build to its blueprint. Discussions around cladding and weathertightness exemplify this point well.

Tensions between professional groups were evident in other responses, including a lack of guidance from MBIE regarding fire-rated cladding, the lack of detailed product specifications from suppliers and a lack of faith in the abilities of BCAs to assess complex design against compliance criteria. This shows that, while industry stakeholders do encounter technical issues with MDH, in some cases, this relates to factions within the building industry feeling that they are not getting the information they need or that certain individuals do not have the ability to understand information provided.

This finding is consistent with two papers on MDH discussed earlier in this report (Palmer, 2014; Dunbar & McDermott, 2011).Within the context of MDH developments in Australia, Palmer rejects the notion that the built environment can be analysed in

isolation from the human interactions that influence how MDH is developed and that to implement change in any given system requires a broader understanding of the complexity of that system, including its network of professionals and information pathways. This view suggests that, rather than treating all technical issues as individual problems to be solved, a broader and deeper analysis is needed to understand the professional environment in which these problems develop. This changes the conversation about MDH because it frames some technical issues as less built-environment specific than as a consequence of flaws within existing procedural and communication systems whereby MDH is designed, consented and constructed.

Studying MDH in New Zealand, Dunbar and McDermott similarly found that New Zealand lacks a coordinated approach to MDH development and that there are inconsistencies among and within agencies as well as a lack of trust amongst all key parties involved in design and construction. Without alignment of objectives among different stakeholder groups, Dunbar and McDermott maintain that it is unlikely that MDH developments will be achieved in a satisfactory manner. They conclude that this may call for institutional and procedural changes that commit key industry players to collaborating through a more integrated course of planning, design and implementation.

Our research suggests that this recommendation remains applicable within the present context. Although common issues were identified in our research, conflicting opinions regarding their cause shows that, rather than there being a singular perspective on technical issues, several perspectives within the industry appear to comprise a cycle of blame amongst building professionals. This raises a challenge for this study and for future MDH research because it suggests that to address technical issues in MDH will (in some cases) require changes to how the building industry operates. Accordingly, future assessments of technical issues that affect MDH from an industry perspective should be complemented by an assessment of the organisational and procedural issues that give rise to them.

6.2 Recommendations for further research

6.2.1 Awareness of solutions

Although this research has identified several technical issues affecting MDH as raised by industry stakeholders, it has not identified what previous work has been done to solve these issues and the extent to which these solutions have been successful.

Accordingly, future research should seek to identify what solutions have already been devised (if any) to address the problems raised and the reasons why the issues continue to persist. Such research would identify what solutions have been developed, the extent of industry awareness of these solutions and any barriers to their implementation.

6.2.2 Design

Design-related issues stood out in this study and underlie many of the responses received. This was evident in responses that covered a lack of information regarding fire design requirements and the lack of integration between design disciplines, where one aspect of design is developed at the expense of others. An example is structural design neglecting the pathway of building services. A lack of detail and overly complex design were also raised in terms of challenges for consent and buildability, as was the

abilities of building officials and contractors to comprehend MDH plans presented for consent and construction.

This suggests that design issues are at the centre of many problems facing MDH. Recognising this, future research regarding design could focus on:

- how to integrate design disciplines to meet requirements pertaining to building structure, building services, fire safety, acoustics and weathertightness
- developing guidelines and/or training modules on the extent of detailing required for MDH consent and construction
- identifying the MDH design training needs of contractors
- solutions for common design issues such as problems with cladding junctions.

6.2.3 Materials and installation

Other potential areas of research relate to the correct selection and installation of materials. Examples were raised during the study where there was uncertainty about selecting correct materials (for example, owing to a lack of quality fire-rated timber products) or how materials should be installed (for example, owing to a lack detail in design in the product specifications). This indicates a lack of information to guide building professionals in this area. Accordingly, future research in this area could focus on:

- product specification requirements for contractors and BCAs.
- correct installation methods for commonly used MDH-related products
- the development of materials that conform to structural, fire and acoustic requirements
- managing the relationship between different cladding systems to ensure weathertightness.

6.2.4 NZS 3604:2011 and the Building Code

Compliance was another issue present in many of the themes identified in this paper. Responses revealed uncertainty regarding how NZS 3604:2011 and Building Code clause E2 *External moisture* apply to buildings above a certain height. Confusion with how to comply with clause E3 *Internal moisture* and difficulty interpreting clause C *Protection from fire* was also raised. This suggests that there are either gaps in how some building regulations apply to MDH or that regulatory information is difficult to access or is simply not understood.

To address this, future research could focus on asking the building industry what needs to change so that compliance is easier to achieve.

6.2.5 Procedural and organisational issues

While this research has identified specific technical issues, in some instances, these issues relate to how building professionals work together. Examples from the research include responses indicating a lack of integrated design and tension between designers and builders. This points to the interdependent yet presently fragmented nature of the building industry where professional groups have their own distinct roles yet also depend on relationships with other parties. Evidence of a fragmented and combative industry culture suggests greater cohesion between professional groups within the building and construction industry is key to minimising technical issues in MDH.

This presents a different opportunity for future MDH research – one that ties directly to the goals set in the government's Construction Sector Accord, which was publicly announced on 14 April 2019. The stated purpose of the Accord is "to strengthen the partnership between government and industry to be a catalyst to transform the construction sector for the benefit of all New Zealand".[5] Of relevance to this research, two of the Accord's guiding principles are listed as 'building trusting relationships' and 'acting with collective responsibility'. Within these principles, the Accord seeks to encourage the industry to work in a collaborative and inclusive way and to promote behaviours that cultivate trust and respect.

The intentions of the government's Construction Sector Accord appear to resonate with the findings of this study, which established that addressing technical issues in MDH will in some cases require changes to how the industry operates. This suggests that future research focused on what institutional and procedural changes are required to commit industry players to collaborating through a more integrated course of planning, design and implementation will help further the Accord's stated objectives.

[5] www.constructionaccord.nz/the-accord/

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Appendix A: Online survey

MDH Technical Issues

Technical Issues facing Medium-Density Housing

Researchers at BRANZ are currently exploring and identifying the technical issues that the industry is encountering with medium-density housing (here defined as multi-unit dwellings up to six-storeys). The results of this study will inform future research projects under the BRANZ medium-density housing research programme, allowing us to ask specific questions about the technical issues being faced by the industry and how best to address these.

BRANZ (Building Research Association of New Zealand) is New Zealand's independent and impartial research, testing, and consulting organisation. We work with the building and construction industry to provide better buildings for New Zealanders. The BRANZ Incorporated Strategy is a non-profitable investor in industry good research and knowledge transfer. We invest in research and information to achieve benefits for New Zealanders by improving the knowledge base of the building and construction industry.

All responses will be treated as confidential and anonymous. You will not be required to provide any identifying information. Completion of this survey is taken as informed consent for your participation. Should you want more information or advice regarding participation in this survey, please contact Anne Duncan at anne.duncan@branz.co.nz

This research has ethical approval from BRANZ's external human ethics advisor, in accordance with BRANZ's human ethics policy.

Thank you for your participation.

MDH Technical Issues

About you

* Where are you primarily located?

- ○ Northland
- ○ Auckland
- ○ Waikato
- ○ Bay of Plenty
- ○ Gisbourne
- ○ Hawke's Bay
- ○ Taranaki
- ○ Manawatu-Whanganui
- ○ Wellington
- ○ Tasman
- ○ Nelson
- ○ Marlborough
- ○ West Coast
- ○ Canterbury
- ○ Otago
- ○ Southland

* Within which sector do you work?

- ○ Architecture, Design, Urban Design, & Planning
- ○ Building Officials & Building Surveying
- ○ Building & Construction Trades
- ○ Business Consultancy
- ○ Central Government
- ○ Civil Infrastructure Trades
- ○ Education
- ○ Electricity Supply Infrastructure
- ○ Other (please specify)
- ○ Land Surveying
- ○ Professional Engineering
- ○ Property & Facilities Management
- ○ Quantity Surveying & Project Management
- ○ Scaffolding, Rigging, & Rope Access
- ○ Science & Research
- ○ Water & Wastewater Trades

* What is your current role in the industry?

MDH Technical Issues

Your experience with medium-density housing

* How long have you worked with medium-density housing for?

- ○ Less than 6 months
- ○ 6-12 months
- ○ 1-5 years
- ○ 5-10 years
- ○ More than 10 years

* How often do you work with medium-density housing?

- ○ Rarely
- ○ Occasionally
- ○ Regularly

* What typologies of medium-density housing have you worked with? (tick all that apply)

- ☐ 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- ☐ 2-4-storey attached houses (e.g. 2-4-storey terraced housing)
- ☐ Up to 6-storey apartments

MDH Technical Issues

Experience with Technical Issues

The following section will ask you to identify any technical issues that you have encountered with medium-density housing, once an issue has been identified you will be asked to provide more information.

A technical issue could be something that is often a problem on the building site, or that is challenging to get right. This could pertain to a specific element (e.g. framing hold down bolts), a part of the building (e.g. facade), or a code requirement (e.g. acoustic design).

* Have you encountered a technical issue with medium-density housing?

- ◯ Yes
- ◯ No

* What are the top five technical issues that you have encountered with medium-density housing?

Issue 1

Issue 2

Issue 3

Issue 4

Issue 5

Do any of the technical issues you have identified occur more frequently than the others? If yes, please describe:

MDH Technical Issues

* Regarding Issue 1 - {{ Q8.R1 }}, what typology of medium-density housing was this issue in relation to?

- [ ] 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- [ ] Up to 6-storey apartments
- [ ] 2-4-storey attached houses (e.g. 2-4-storey terraced housing)

Do you wish to describe this issue further?

* How much of an impact did this issue have?

- ( ) No impact
- ( ) Low impact (minimal effort to fix)
- ( ) Medium impact (potential risk to occupants in some circumstances)
- ( ) High impact (potential risk to occupants, becomes uninhabitable, significant rework needed)
- ( ) Severe impact (major risk to occupants, uninhabitable, significant rework needed)

* Please describe the impact this issue had:

* How often do you come across this issue?

- ( ) Rarely - on one or two building sites
- ( ) Occasionally
- ( ) Regularly - on nearly all building sites

* What needs to change to resolve this issue?

- ( ) Building code clause revision or new standard
- ( ) Training
- ( ) Other (please specify)
- ( ) Improved detailing

MDH Technical Issues

* Regarding Issue 2 - {{ Q8.R2 }}, what typology of medium-density housing was this issue in relation to?

- [ ] 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- [ ] Up to 6-storey apartments
- [ ] 2-4-storey attached houses (e.g. 2-4-storey terraced housing)

Do you wish to describe this issue further?

* How much of an impact did this issue have?

- ( ) No impact
- ( ) Low impact (minimal effort to fix)
- ( ) Medium impact (potential risk to occupants in some circumstances)
- ( ) High impact (potential risk to occupants, becomes uninhabitable, significant rework needed)
- ( ) Severe impact (major risk to occupants, uninhabitable, significant rework needed)

* Please describe the impact this issue had:

* How often do you come across this issue?

- ( ) Rarely - on one or two building sites
- ( ) Occasionally
- ( ) Regularly - on nearly all building sites

* What needs to change to resolve this issue?

- ( ) Building code clause revision or new standard
- ( ) Training
- ( ) Other (please specify)
- ( ) Improved detailing

MDH Technical Issues

* Regarding Issue 3 - {{ Q8.R3 }}, what typology of medium-density housing was this issue in relation to?

- [ ] 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- [ ] Up to 6-storey apartments
- [ ] 2-4-storey attached houses (e.g. 2-4-storey terraced housing)

Do you wish to describe this issue further?

* How much of an impact did this issue have?

- ( ) No impact
- ( ) Low impact (minimal effort to fix)
- ( ) Medium impact (potential risk to occupants in some circumstances)
- ( ) High impact (potential risk to occupants, becomes uninhabitable, significant rework needed)
- ( ) Severe impact (major risk to occupants, uninhabitable, significant rework needed)

* Please describe the impact this issue had:

* How often do you come across this issue?

- ( ) Rarely - on one or two building sites
- ( ) Occasionally
- ( ) Regularly - on nearly all building sites

* What needs to change to resolve this issue?

- ( ) Building code clause revision or new standard
- ( ) Training
- ( ) Other (please specify)
- ( ) Improved detailing

MDH Technical Issues

* Regarding Issue 4 - {{ Q8.R4 }}, what typology of medium-density housing was this issue in relation to?

- [ ] 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- [ ] Up to 6-storey apartments
- [ ] 2-4-storey attached houses (e.g. 2-4-storey terraced housing)

Do you wish to describe this issue further?

* How much of an impact did this issue have?

- ( ) No impact
- ( ) Low impact (minimal effort to fix)
- ( ) Medium impact (potential risk to occupants in some circumstances)
- ( ) High impact (potential risk to occupants, becomes uninhabitable, significant rework needed)
- ( ) Severe impact (major risk to occupants, uninhabitable, significant rework needed)

* Please describe the impact this issue had:

* How often do you come across this issue?

- ( ) Rarely - on one or two building sites
- ( ) Occasionally
- ( ) Regularly - on nearly all building sites

* What needs to change to resolve this issue?

- ( ) Building code clause revision or new standard
- ( ) Training
- ( ) Other (please specify)
- ( ) Improved detailing

MDH Technical Issues

* Regarding Issue 5 - {{ Q8.R5 }}, what typology of medium-density housing was this issue in relation to?

- [ ] 1-2-storey attached houses (e.g. one-storey units; 1-2-storey duplexes/triplexes; semi-attached terraced housing)
- [ ] Up to 6-storey apartments
- [ ] 2-4-storey attached houses (e.g. 2-4-storey terraced housing)

Do you wish to describe this issue further?

* How much of an impact did this issue have?

- ( ) No impact
- ( ) Low impact (minimal effort to fix)
- ( ) Medium impact (potential risk to occupants in some circumstances)
- ( ) High impact (potential risk to occupants, becomes uninhabitable, significant rework needed)
- ( ) Severe impact (major risk to occupants, uninhabitable, significant rework needed)

* Please describe the impact this issue had:

* How often do you come across this issue?

- ( ) Rarely - on one or two building sites
- ( ) Occasionally
- ( ) Regularly - on nearly all building sites

* What needs to change to resolve this issue?

- ( ) Building code clause revision or new standard
- ( ) Training
- ( ) Other (please specify)
- ( ) Improved detailing

MDH Technical Issues

Is there anything else that you encounter regularly in the design and/or construction of MDH that you would like to include?

MDH Technical Issues

Thank you

If you are willing to be contacted for a follow-up discussion of the issues identified, please enter your contact details below, otherwise leave blank.

Email Address

Phone Number

If you would like to go into the draw to win an Apple iPad, please enter your email address below:

MDH Technical Issues

Thank you for your time. If you have any further questions or comments regarding this research, please contact Anne Duncan, anne.duncan@branz.co.nz

Appendix B: Survey responses and analysis

Survey respondents

An invitation to participate in this survey was sent via email to a wide range of industry representatives using the BRANZ database. In total, 7,082 emails were sent out, and 334 individuals clicked through to the survey.

Of those who clicked on the survey attachment, 292 participants completed some or all of the survey. This represents a click rate of 4.7% and a completion rate of 4.1%. Where relevant, partial responses have been included in the analysis. Forty individuals clicked through to the survey more than once, which suggested that those recipients forwarded it on to colleagues.

Figure 6 presents the geographical spread of participants. The highest percentage of respondents were from Auckland, with 44% of respondents indicating they worked in the region. Canterbury formed the second-largest group (20%), while Wellington was third (13%). The high proportion of respondents from these major urban regions is due to the survey being targeted towards those involved in MDH in major New Zealand cities (where the majority of MDH occurs).

The remaining 23% of respondents were spread across New Zealand. Note that Northland, Gisborne, Taranaki, Tasman, Marlborough and West Coast have been excluded from Figure 6 as no respondents worked in these regions.

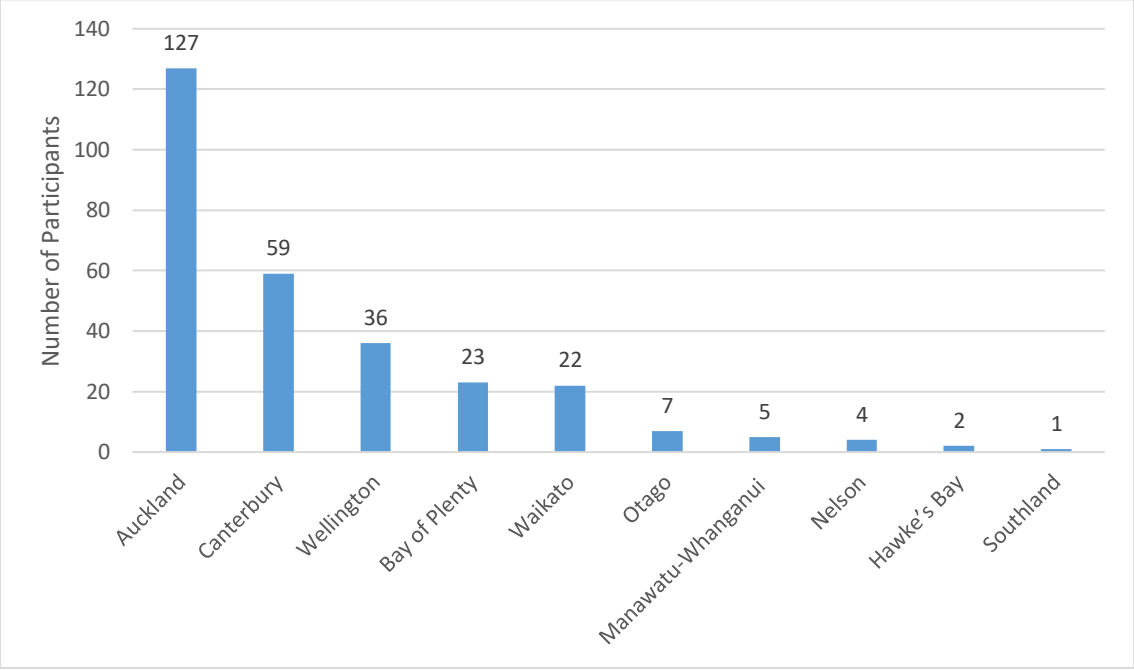

Figure 6. Geographical spread of participants.

Table 2 presents the sector of the industry that participants work within.

The majority of respondents (44%) worked in design and planning (listed as architecture, design, urban design, and planning). The second-largest sector represented was building and construction trades (20%), and the third-largest sector was building officials and building surveying (18%).

Table 2. Sector of the building industry in which participants work.

Industry sector	Number of participants	Percentage
Architecture, Design, Urban Design, & Planning	124	43.5%
Building & Construction Trades	55	19.3%
Building Officials & Building Surveying	50	17.5%
Professional Engineering	26	9.1%
Other	11	3.9%
Quantity Surveying & Project Management	8	2.8%
Central Government	5	1.8%
Property & Facilities Management	3	1.1%
Business Consultancy	2	0.7%
Education	1	0.4%
Total	**285**	**100%**

Figure 7 illustrates the industry sectors by region that are represented within this study. The majority of participants across all regions were from the architecture and design sector, with more the half of participants from Wellington and Auckland working in this area. Building officials and those working in trades were more or less evenly represented, with the remainder of participants working in professional engineering.

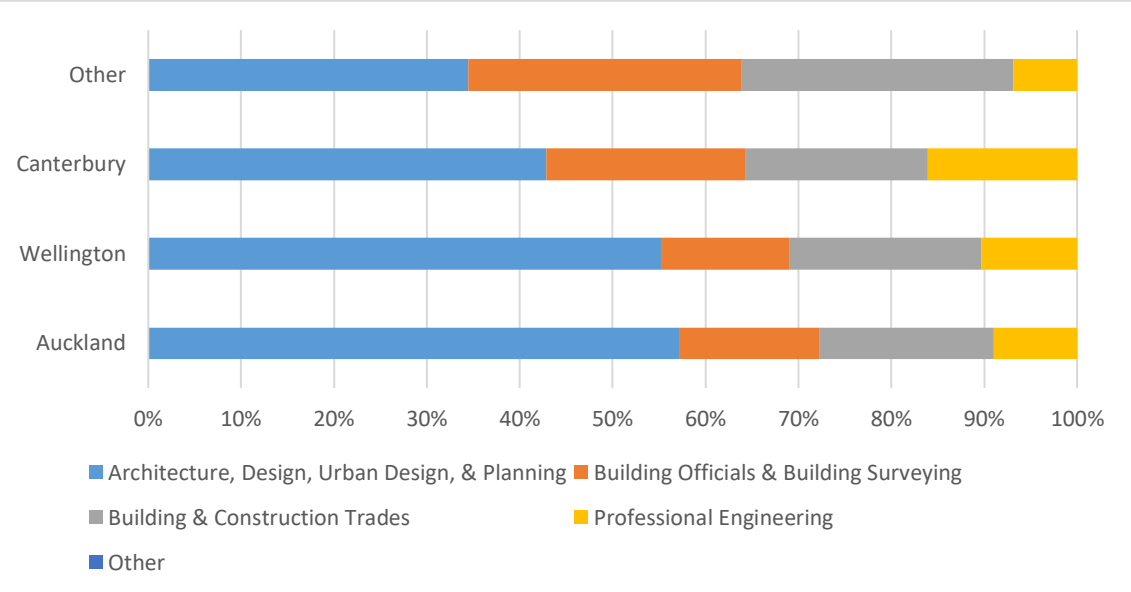

Figure 7. Breakdown of industry sectors by region.

Experience with MDH

The majority of participants (92%) indicated that they had previous experience working with MDH. A large proportion of the study sample (43%) indicated they had worked with MDH for more than 10 years. The second-largest group had worked with MDH for 1–5 years (28%), 13% of respondents had worked with MDH for 5–10 years, while the remaining 15% of participants indicated less than 12 months' experience with MDH.

Of those who had experience with MDH, 43% worked with MDH on a regular basis, 35% occasionally and the remainder worked with MDH on rare occasions.

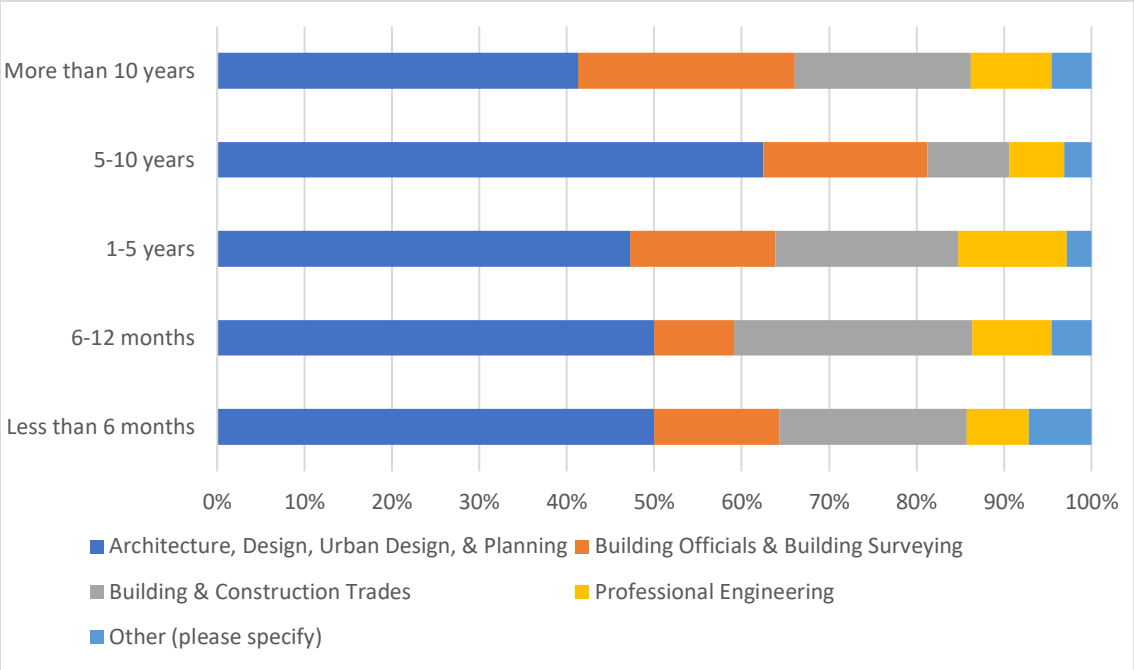

Figure 8. Length of time working with MDH by industry sector.

Each respondent was asked to identify any technical issues they had encountered in their work with MDH. Overall, 87% of participants had encountered at least one technical issue with MDH. Unsurprisingly, the research established that the more time participants worked with MDH, the more likely they were to identify a technical issue.

Appendix C: Workshops

Workshop methods

An invitation to register for the workshops was sent out to the BRANZ database via Mailchimp. The BRANZ marketing and communications team sent invitations to a wide range of industry representatives (builders, engineers, project managers, BCAs, architects and designers) based in Queenstown, Christchurch, Wellington and Auckland. The rationale for this was that most MDH development in New Zealand is in these cities. Participants were offered a free lunch and a $50 voucher if they attended the workshop. The Auckland workshop filled up quickly, so two additional workshops were added. The workshops ran for 4 hours (including 30 minutes for lunch).

Workshop participants

In total, 80 participants attended the six workshops – one in Queenstown, one in Christchurch, one in Wellington and three in Auckland. 75 participants filled out the "About You Questionnaire". Table 3 and Figure 9 present the geographical spread of participants in the six workshops. Virtually all of the participants worked in the city in which they attended the workshop (outside of one Auckland participant at the Wellington workshop). 60% of all the participants in the six workshops worked in Auckland. The remaining participants were divided roughly equally between the Queenstown, Christchurch and Wellington workshops.

Table 3. Geographical spread of workshop participants.

Region	Number of participants per workshop	Number of participants per city	Percentage per city
Queenstown	10	10	12.5%
Christchurch	11	11	14.7%
Wellington	11	11	14.7%
Auckland – 1 Auckland – 2 Auckland – 3	20 9 19	48	60%
Total	**80**	**80**	**100%**

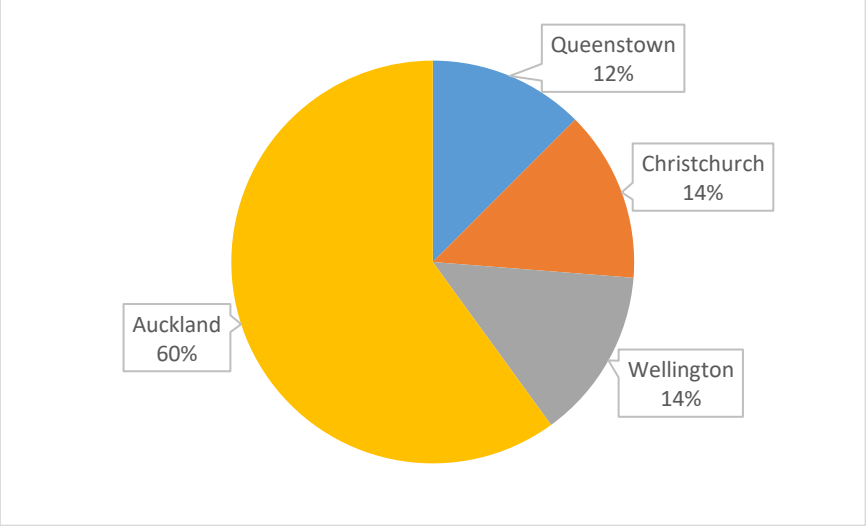

Figure 9. Geographical spread of workshop participants.

Workshop participants (the 75 who filled out this form) selected which sector of the building and construction industry they worked in, and some individuals selected more than one industry sector. Table 4 and Figure 10 present the sector of the industry that participants work within. The majority of participants (91%) worked in design and planning (listed as architecture, design, urban design, and planning). The second-largest sector represented was building and construction trades (16%), the third-largest was central government (11%) and the fourth-largest was professional engineering (9%).

Table 4. Sector of the building industry in which workshop participants work.

Industry sector	Number of participants	Percentage
Architecture, Design, Urban Design, & Planning	68	91%
Building & Construction Trades	12	16%
Central Government	8	11%
Professional Engineering	7	9%
Other	4	5%
Quantity Surveying & Project Management	4	5%
Building Officials & Building Surveying	2	3%
Business Consultancy	2	3%
Education	2	3%

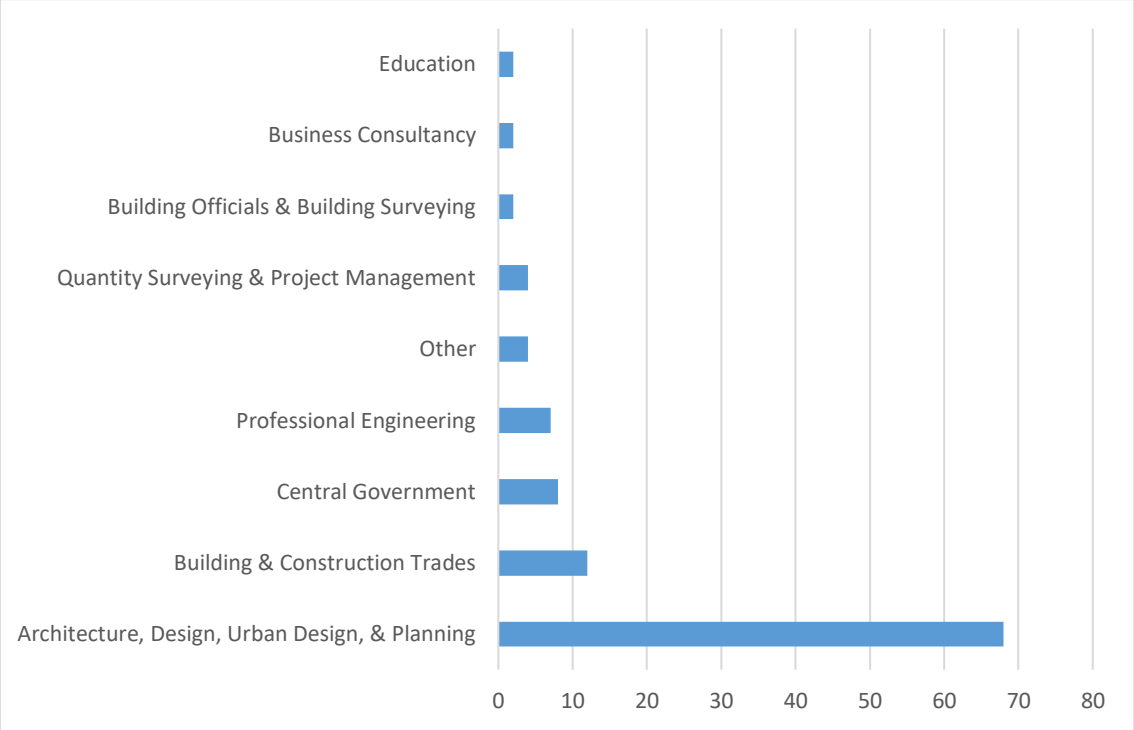

Figure 10. Sector of the building industry in which workshop participants work.

All of the 75 workshop participants who responded had worked with MDH for some period of time.

Table 5 and Figure 11 show that 33% indicated that they had worked with MDH for more than 10 years. The second-largest group had worked with MDH for 1–5 years (31%), 24% had worked with MDH for 5–10 years, while the remaining 12% had 1 year or less experience with MDH.

Table 5. Length of time working with MDH.

Length of time	Number of participants	Percentage
More than 10 years	25	33%
5–10 years	18	24%
1–5 years	23	31%
6–12 months	3	4%
Less than 6 months	6	8%
Total	**75**	**100%**

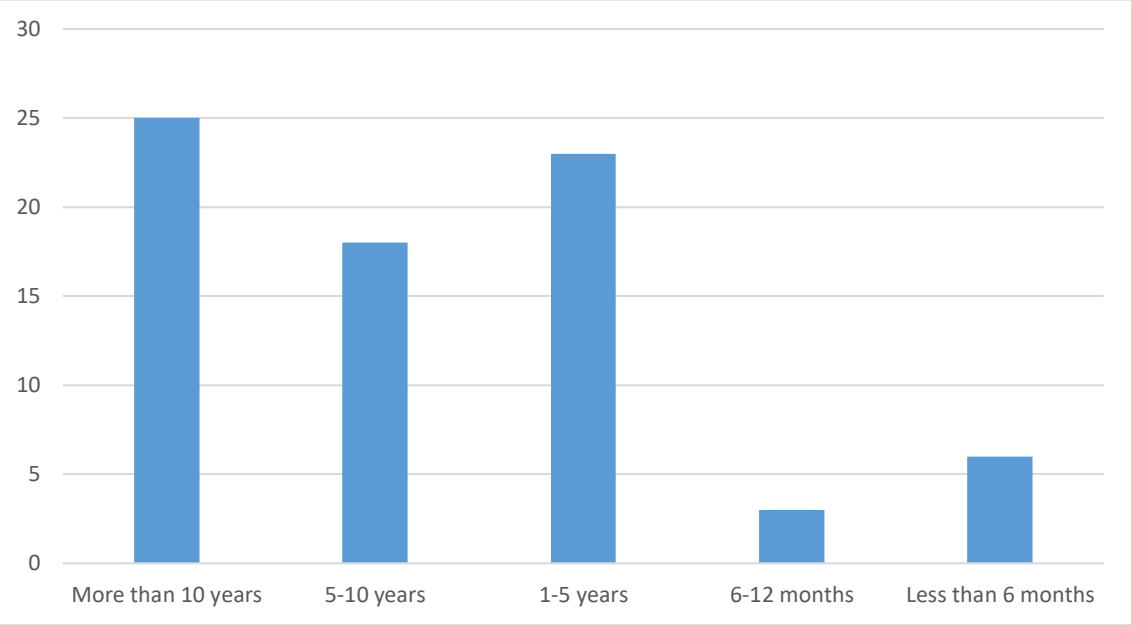

Figure 11. Length of time working with MDH.

Table 6 and Figure 12 show how often the workshop participants indicated that they worked with MDH. Of the 75 workshop participants, the majority (58%) had worked with MDH on a regular basis, 37% occasionally, and the remainder (5%) worked with MDH on rare occasions.

Table 6. How often workshop participants worked with MDH.

How often	Number of participants	Percentage
Regularly	43	58%
Occasionally	28	37%
Rarely	4	5%
Total	**75**	**100%**

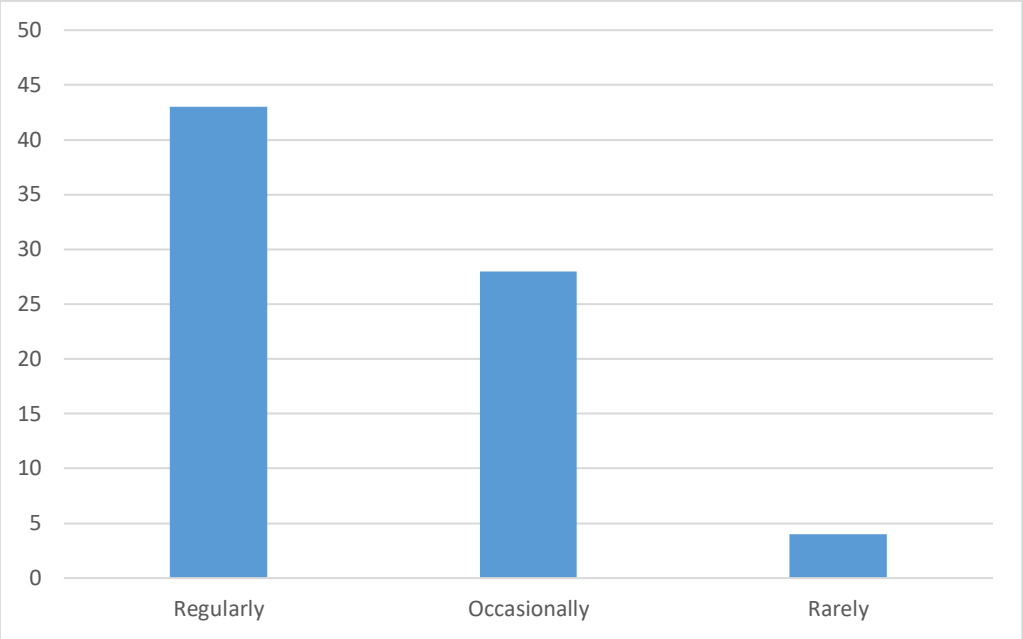

Figure 12. How often workshop participants worked with MDH.

Table 7 and Figure 13 show what typologies of MDH the workshop participants worked with. Some participants selected more than one typology. A large proportion of the workshop sample (80%) worked with 1–2-storey attached houses, 63% worked with 2–4-storey attached houses and almost half (47%) worked with apartments up to 6 storeys.

Table 7. What typologies of MDH workshop participants worked with.

Typologies	Number of participants	Percentage
1–2-storey attached houses	60	80%
2–4-storey attached houses	47	63%
Apartments up to 6 storeys	35	47%

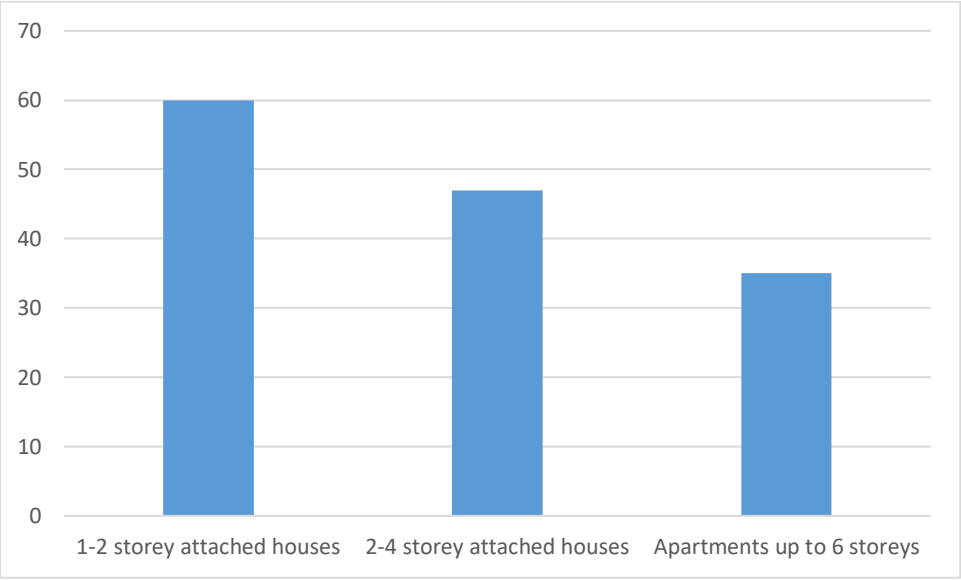

Figure 13. What typologies of MDH workshop participants worked with.