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Industry perceptions of weathertightness failure in residential construction

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Preface

This report focuses on industry perceptions of weathertightness failure within residential construction. It investigates industry beliefs regarding the prevalence of the problem in residential new builds, why the issue persists and how it can be mitigated.

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Abstract

This report investigates industry perceptions of why weathertightness issues persist in residential construction and how these issues can be mitigated. The research methods used include an online survey, focus groups and in-depth interviews with key industry stakeholders. The problems identified by research participants suggest that the persistence of external water leakage in new residential builds can be attributed to a systems failure within the industry. Discussing with study participants how modern cases of weathertightness failure can be mitigated, many of the solutions posited seek to address facets of how the building and construction industry operates, reflecting a belief that some of the mechanisms that guide how the industry functions paradoxically create conditions that undermine building quality.

Keywords

Weathertightness, weathertightness failure, building industry, industry perceptions, solutions.

Disclaimer

This research presents the views of the research participants, which do not necessarily represent the views of BRANZ.

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Executive summary

This report investigates industry beliefs about why weathertightness issues persist in new residential builds and how these issues can be mitigated. Following recent studies on the topic (Page, 2014; Curtis & Gordon, 2018; Nuth & Duncan, 2019; Dyer, 2019), a body of research exists that suggests external water ingress remains a problem within the residential sector. This raises a question whether legacy issues from the leaky housing crisis of the 1990s and early 2000s continue to affect the residential building sector or whether a new range of issues have since emerged.

As the leaky housing crisis showed, well intended housing policy can sometimes have unintended consequences. When residential dwellings were built under the performance-based regulatory regime of the 1990s and early 2000s, few could have foretold the scheme's impact on individuals, families and the industry at large. Given indications that leaky housing is still a problem, there is an opportunity to ask the industry about why weathertightness remains an issue and how it can be resolved.

Investigating this topic involved an online survey of over 200 building professionals and a series of focus groups and interviews with industry stakeholders about the causes of ongoing weathertightness failure in the residential sector. Of fundamental interest during the research was whether New Zealand's regulatory framework for building and construction is perceived by industry as being sufficiently robust to prevent another systematic failure or whether modern causes of external water ingress extend beyond the reach of the procedural and technical controls of the New Zealand Building Code.

Overview of findings

Feedback from industry suggests that a multitude of interrelated causes underlie ongoing cases of external water ingress.

As raised by our research subjects, this encompasses issues such as:

- variable levels of skill and professionalism amongst contractors within the building workforce
- variable levels of practical building knowledge amongst designers
- a licensing scheme for builders that some industry professionals believe has failed to raise building standards
- limited independent construction observation
- a regulatory environment that some professionals believe is predicated on compliance rather than building performance.

Industry feedback further indicates that these issues are underpinned by a consumer environment in which the desire for housing affordability is prioritised above concerns about construction quality. Professionals from a range of disciplines within the study note that building standards in New Zealand are often affected by a consumer market where clients largely gravitate towards low-cost contractors (who often demonstrate themselves to be less capable) to limit total project cost. According to those we spoke to, this relates to a misperception amongst consumers about what constitutes value for money in construction, allowing less-capable builders to gain a foothold within the market.

These perceptions suggest that the persistence of weathertightness failure can be attributed to a systems failure within the building industry that exists partly outside of

regulatory control. Discussing with study participants how modern cases of weathertightness failure can be mitigated, many recommended addressing facets of how the building and construction industry operates. This reflects a belief that some of the mechanisms that guide how the industry functions paradoxically create conditions that could lead to weathertightness failure.

Table 1 summarises the identified problems, issues, impacts and solutions related to weathertightness failure.

Table 1. Problems identified by the industry that contribute to poor weathertightness and recommended solutions.

Industry-identified problem	Industry-identified issue	Industry-identified impact	Industry-recommended solution
Consumer price sensitivity	Building quality is influenced by price-sensitive consumers. Some clients prefer low-cost contractors.	Increases the likelihood of less-experienced/capable builders winning contracts and dictating market conditions.	Educate clients on the benefits of hiring an independent consultant to observe construction on their behalf.
	Clients cut out construction monitoring from architects' contracts to save money.	Lack of independent oversight of underskilled workers.	
Joint and several liability	Architects reluctant to act as quality assurers on site from concerns around liability unless engaged on a full contract.	Risk of liability can act as a disincentive for architects to visit building sites on behalf of their clients if not on a full contract.	Introduce proportional liability. Increase the number of Acceptable Solutions in Building Code clause E2.
	Fear of liability is driving negative behaviours in BCAs in how they assess consent applications.	Owing to the risk of liability, BCAs are seen to prefer E2 Acceptable Solutions even if they are not suitable, forcing designers to use solutions that give poorer performance.	
Design quality	A lack of practical building knowledge among some designers.	A lack of practical knowledge can make it difficult for architects to understand what information builders need to turn design concepts into reality. This undermines the buildability of designs.	Increase architects' knowledge base by increasing the degree of on-site experience graduate architects receive during their education. Introduce a builder's perspective to design before construction. Increase use of 3D drawings.
Poor contractor execution of installation specifications	There is a market for less-skilled contractors and those who rely on ways of working based more on old habits than keeping up with industry standards.	Poor product installation leading to weathertightness failure.	Reform the current apprenticeship training scheme covering who can teach, what is being taught and how it is being taught. Combine the training of professions to allow for greater cohesion and understanding in industry around weathertightness implementation.
	Contractors often do not have the time to fully review product installation specifications before starting work.	Poor product installation leading to weathertightness failure.	Tailor information to meet the needs of tradespeople who lack time to read complex resources that are difficult to obtain. Promote greater use of digital technology. Promote greater integration of mobile apps so information is easier to find.
Limited quality assurance	The LBP Scheme has been largely ineffective at raising building standards.	There are low-skilled or dishonest builders who have met licensing criteria and get away with substandard work.	Reform the LBP Scheme to better ensure Code compliance and raise overall building quality and guarantees that industry members are accountable for their work.

1. Introduction

1.1 Context

'Weathertightness failure' is a familiar term within New Zealand's building vernacular, largely owing to New Zealand's leaky housing crisis, which emerged in the early 2000s. This spelled a difficult period in the building and construction industry's history and resulted in several governmental reviews to determine how regulatory changes that aimed to foster innovation could result in the large-scale dilapidation of residential dwellings (Hunn, Bond & Kernohan, 2002).

The leaky housing crisis showed that, although housing policy can be formed with the best of intentions, it can also be blind to its long-term consequences. When residential dwellings were built under the performance-based regulatory scheme of the 1990s and early 2000s, few could have predicted the scale of the scheme's future impact. Although a range of regulatory changes were enacted in response to the leaky housing crisis (which were embodied by the Building Act 2004), experiences of the 1990s and early 2000s suggest that there is a need to maintain a critical perspective about how the industry and the regulatory framework that governs it act to prevent external moisture from penetrating the building envelope.

This is especially pertinent now given the body of evidence suggesting that weathertightness failure remains a pressing issue within residential construction. Despite changes to the Building Act in 2004 aimed at reducing instances of external water penetration, several BRANZ studies have subsequently established that external water ingress is a problem in many newly built homes (Page, 2014; Curtis & Gordon, 2018; Nuth & Duncan, 2019). The findings of these studies have been further reinforced by the recently published book *Rottenomics* (Dyer, 2019), which draws attention to the continuation of newly built leaky houses in New Zealand today.

While even well designed and constructed buildings can leak, this report makes a distinction between ordinary cases of external water ingress and cases where water ingress is not being sufficiently managed.[1] Based on research that suggests weathertightness issues do persist within the residential sector, this study focuses on industry beliefs about why external water ingress remains a problem in some new builds. Gauging this involved an online survey of building professionals (including architects, builders, building surveyors, engineers and building inspectors) about the causes of the issue. This was complemented by a series of focus groups and semi-structured interviews with members of the building industry to get their insight into why new residential buildings leak and what can be done to mitigate the problem.

1.2 Definition and terms

Section 8 of the Weathertight Homes Resolution Services Act 2006 defines a leaky building as "a dwellinghouse into which water has penetrated as a result of any aspect of the design, construction, or alteration of the dwellinghouse, or materials used in its construction or alteration".

For the purpose of this report, 'weathertightness failure' refers to a flaw in how a residential dwelling was designed or constructed to manage external moisture.

[1] Owing to deficiencies in design or in product installation.

2. Methodology

2.1 Research question

This study report investigates industry beliefs about why weathertightness issues persist in residential construction, with a focus on builds aged 10 years or less.[2] This links to BRANZ's broader aim to understand why quality issues persist in new builds, particularly where they are of high impact. As identified in earlier BRANZ research, although there are several pressing technical issues in residential construction, external water ingress appears to be both high impact and widespread (Curtis & Gordon, 2018). Consequently, this research focuses on weathertightness failure as a quality issue that requires specific attention.

2.2 Project aim

By studying industry perceptions about the persistence of leaks affecting parts of houses not designed to get wet, the research sought to identify whether building professionals believe that modern cases of external water ingress is a problem that lies beyond the solutions in E2/AS1 of the Building Code.

2.3 Literature review

A selection of articles within the broad literature on weathertightness were reviewed to summarise why weathertightness failure became a significant problem in the 1990s and early 2000s and the various solutions that were consequently employed via the Building Act 2004. This information was used as context to present-day concerns about external water ingress and provided background to industry views about the effectiveness of the solutions.

The literature review also extended to more recent studies on the topic, which were used to verify that weathertightness failure is an issue presently affecting the industry. Here, several BRANZ study reports and external publications on persisting building quality issues were cited to support the view that weathertightness failure remains an ongoing problem.

2.4 Data collection

The collection of empirical data utilised a mixed-methods approach, including an online survey, a series of focus groups and several semi-structured interviews with building professionals. Secondary research involved a review of relevant literature. All primary data was assessed via a thematic analysis whereby responses were grouped according to specific overarching themes that emerged during the research. This enabled the author to identify and prioritise a small number of key areas of concern to the building industry within which specific examples were grouped.

Empirical data was initially collected via an online survey.[3] Recruitment for the survey was first undertaken by identifying building professionals within BRANZ's customer database who were most likely to encounter issues with weathertightness failure. This resulted in the author filtering the database to include residentially focused architects,

[2] This time range was chosen because it covers a period when new residential builds should reflect changes made to the Building Act in 2004.
[3] See Appendix A for a copy of the survey questions.

engineers, builders and building surveyors. This narrowed the database down to 869 industry contacts.

A trial version of the survey was first emailed to an initial sample of 100 industry representatives within the database consisting of equal numbers from each of the four professional categories.[4] The objective of trialling the survey with this restricted group was to develop a better understanding of weathertightness issues so that the survey could then be developed to capture more information. This first survey rendition ran from 16 July to 9 August 2019 and attracted a response rate of 11%.

Following a review of responses, the survey was updated and then issued to the remaining 769 industry representatives. The updated survey asked a series of questions about participants' experiences with weathertightness issues, what components of residential housing this most affected and how they felt that the issue should be addressed. The survey ran from 14 August to 21 August 2019 and attracted a response rate of 6.3% (49 individual responses).

To increase the number of responses, from 22 August 2019 to 30 September 2019, individual survey collector links were emailed separately to senior management representatives of six industry bodies[5] with the request to on-send to their respective members. This received an immediate positive response from BOINZ, NZIA, NZCB and RMBA, who each sent the link to their respective members.

In total, 215 individual responses to the online survey were received.

2.5 Key informant interviews and focus groups

Continuing the research, from 15 September to 9 October 2019 BRANZ researchers conducted a series of 13 telephone interviews and four focus groups with key stakeholders to explore issues that arose from the surveys in more depth. Participants were recruited via the online survey, which contained a question asking respondents whether they were interested in participating in further research to discuss the topic of weathertightness in greater detail. This resulted in positive responses from 67 people. From this, 25 building professionals participated in focus group research and 13 participated in personal interviews.[6]

2.6 Ethics

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

[4] The sample was selected at random, and an email explaining the study and containing a URL link was issued directly to each contact.
[5] This included New Zealand Institute of Building Surveyors (NZIBS), Building Officials Institute of New Zealand (BOINZ), New Zealand Institute of Architects (NZIA), Architectural Designers New Zealand (ADNZ), New Zealand Certified Builders Association (NZCB) and Registered Master Builders Association New Zealand (RMBA).
[6] See Appendix C for further detail.

3. Literature review

3.1 Leaky homes

The issue of leaky homes received substantial media attention throughout the early 2000s owing to numerous cases of mainly 1990s-era residential builds suffering from external water ingress and internal rot. Such was the scale of the issue throughout New Zealand, it was ultimately determined to be a systemic problem associated with regulatory change enacted in the early 1990s that loosened restrictions on untested building products such as those used for external cladding and timber framing (Buchanan, Deam, Fragiacomo, Gibson & Morris, 2006).

Until this time, building regulations were largely perceived within the industry as being overly prescriptive, costly and limiting of innovation (Easton, 2010). To promote innovation, in 1991, the government moved away from a prescriptive approach to building regulations to embrace a performance-based regulatory regime, which focused more on building outcomes than on building method. This allowed the building and construction industry greater freedom to employ new construction methods and use non-traditional products (May, 2004).

Relevant to the problems that were to follow, this led to the increased use of direct-fixed monolithic claddings (more commonly used in drier northern hemisphere climates) and the liberalisation of timber durability requirements, which led to the use of untreated *Pinus radiata* to be permitted within all parts of timber-framed residential buildings (Hunn et al., 2002).

The combined use of these materials proved largely unsuccessful. While monolithic cladding provided a popular Mediterranean-style aesthetic, it proved not to be watertight unless used strictly to specification. Since its use coincided with more complicated building designs and construction methods than what had been common in New Zealand until this period, this form of cladding was often penetrable to external moisture and largely unsuited to New Zealand's wet climate (Easton, 2010; PricewaterhouseCoopers, 2009). Further, because it was then uncommon to have a drainage cavity behind this form of cladding, water that penetrated the building exterior was unable to drain away. Owing to the increased use of untreated timber at the time, this led to a situation where the timber framing of 1990s-era residential dwellings began to rot, often without the homeowner's knowledge, until the damage was severe (Dyer, 2019).

The use of untreated timber and the popularity of non-traditional claddings therefore provided the key ingredients for the creation of the phenomenon known as leaky homes. However, other factors amplified its effect. As noted by various authors, the pre-Building Act 2004 environment traditionally saw inspectorate attention focused on the structural integrity of residential dwellings instead of the cladding (May, 2004; Murphy, 2010). It is broadly understood that this is because tried and tested cladding products such as brick and weatherboard were, until then, commonly used and largely trusted. However, with the growing use of non-traditional cladding products, some authors believed that council building inspectors were caught unaware of the increased risk of moisture penetrability (Murphy, 2012).

3.2 Response to the leaky housing problem

A range of regulatory changes were enacted in response to the leaky housing crisis. These were embodied by the Building Act 2004, which led to the tightening of several building procedures and on-site practices.

One of the most impactful changes was the revision of Building Code Acceptable Solution B2/AS1 (durability), which saw the reintroduction of treatment timber requirements in order to prevent the rot of internal framing in areas at risk of external water ingress. This was complemented with a revision of Acceptable Solution E2/AS1 (external moisture), which is noted by some industry commentators as an attempt to prescriptively document standard domestic building practices around the use of flashing and cladding (Murphy, 2012). This included greater emphasis being placed on the use of drained and vented cavities and the introduction of a risk matrix to help building professionals assess the weathertightness risk of low-rise timber-framed buildings.

Other responses to the leaky homes problem included the introduction of the Licensed Building Practitioners (LBP) Scheme in 2007. Developed to formally recognise builders' knowledge and skills, the LBP Scheme was phased in to address the DIY building culture that pervaded the building industry, where self-taught 'builders' could work along their more formally qualified colleagues. The scheme was phased in to address this evident skills deficit and ultimately served to restrict unlicensed builders from undertaking and signing off responsibility for certain types of work, including work associated with the construction or installation of weathertight cladding systems (Murphy, 2012).

3.3 Persistence of weathertightness issues following the Building Act 2004

Despite changes to the Building Act, more recent studies indicate that external water ingress remains a significant issue. In a study of quality issues in New Zealand's residential construction sector, Curtis and Gordon (2018) found that of most concern amongst building professionals were on-site practices that allow moisture to penetrate the building envelope. Specifically, the authors found that these concerns largely related to the use of poor-quality materials, poor workmanship or instances when incompatible materials were used together. The incorrect use or overuse of sealants for weathertight purposes was cited by the study's authors as being a main cause of ongoing weathertightness problems.

Nuth and Duncan's (2019) report on technical issues in medium-density housing (MDH) similarly found that external water ingress ranks as a top concern for this housing typology amongst building professionals, with multiple junctions between cladding systems cited as a major ongoing source of external water ingress. The authors also cited uncertainty amongst building professionals regarding the applicability of Building Code Acceptable Solution E2/AS1 to MDH, as the standards set for external façades during the time of the study only applied to buildings of up to 10 metres in height – not buildings beyond this range that are exposed to greater weather extremes.

The persistence of weathertightness issues in New Zealand's residential construction sector was also highlighted in a study by Page (2014) that involved an inspection of over 200 new detached houses at various stages of construction and a separate survey of builders regarding their experience of quality issues. Of the many compliance

defects identified during inspections, the most common related to the incorrect fixing of windows to the frame and problems with installing flashings. However, from the survey of residential builders, Page also found that many contractors experienced problems with a lack of buildable details on drawings, in particular, roof and wall flashings and connectors – all of which are important to ensure weathertightness.

Most recently, the book *Rottenomics* (Dyer, 2019) collates a wide range of industry opinions on the extent and continuation of the leaky homes crisis. Although the author and many of his interviewees exhibit confidence in the progression made in New Zealand towards remedying the issue, he concludes that the construction of leaky homes is still occurring owing to a perfect storm of a lack of skills, education, professional accountability, material testing and government regulation (Dyer, 2019). Focusing on the role of government, Dyer notes that deregulation of the industry in the 1990s saw a myriad of untested materials enter the market, which, due to pressures for industry professionals to remain commercially competitive, incentivised tradespeople to substitute products that had a history of performance with others that were new and unproven.

Further indicating that ensuring residential weathertightness is a topic of high concern for building professionals, results from recent BRANZ industry needs surveys (BRANZ, 2016, 2019) make clear that the industry continues to seek further prescriptive solutions to instances of external water ingress.

Despite changes brought to the industry to improve weathertightness following the leaky homes crisis, collectively these studies show that weathertightness failure remains a significant industry concern. The aim of this study is to delve deeper into industry views about the causes of this problem and how they can be addressed.

4. Survey analysis

4.1 Extent of weathertightness failure

To gauge how common weathertightness issues are in residential new builds, survey participants were asked whether they have witnessed issues with external water ingress in residential buildings less than 10 years old (Figure 1). Of the 215 survey respondents, 64% (n=137) indicated that they had witnessed such issues.

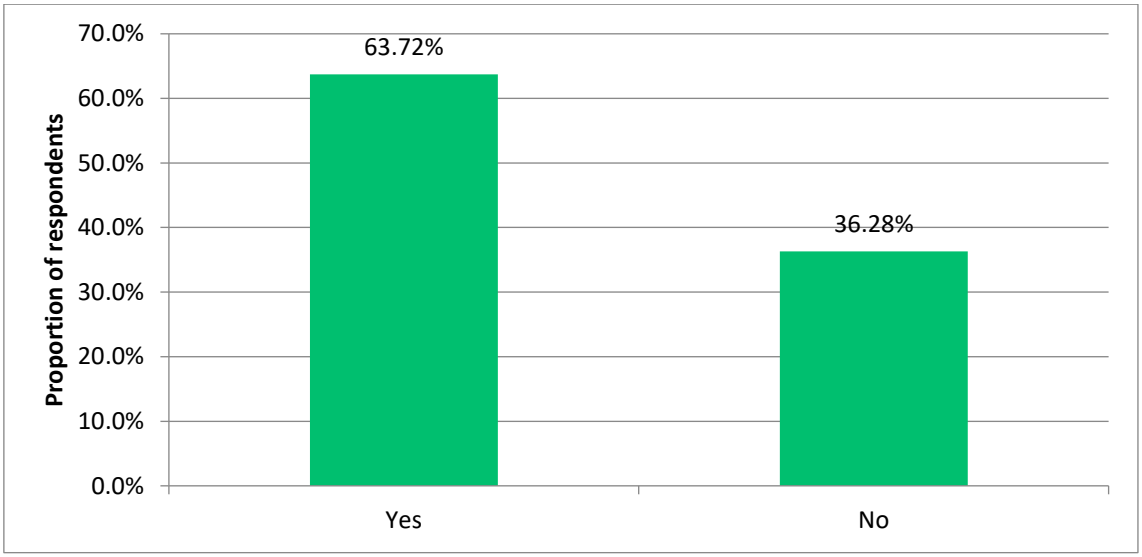

Figure 1. Have you witnessed issues with external water ingress in residential buildings less than 10 years old?

Analysed regionally, the data shows more survey participants had witnessed issues with external water ingress in residential builds than those who had not in each region of the country (Figure 2). This suggests that weathertightness problems within residential buildings aged 10 years or less is experienced throughout New Zealand.

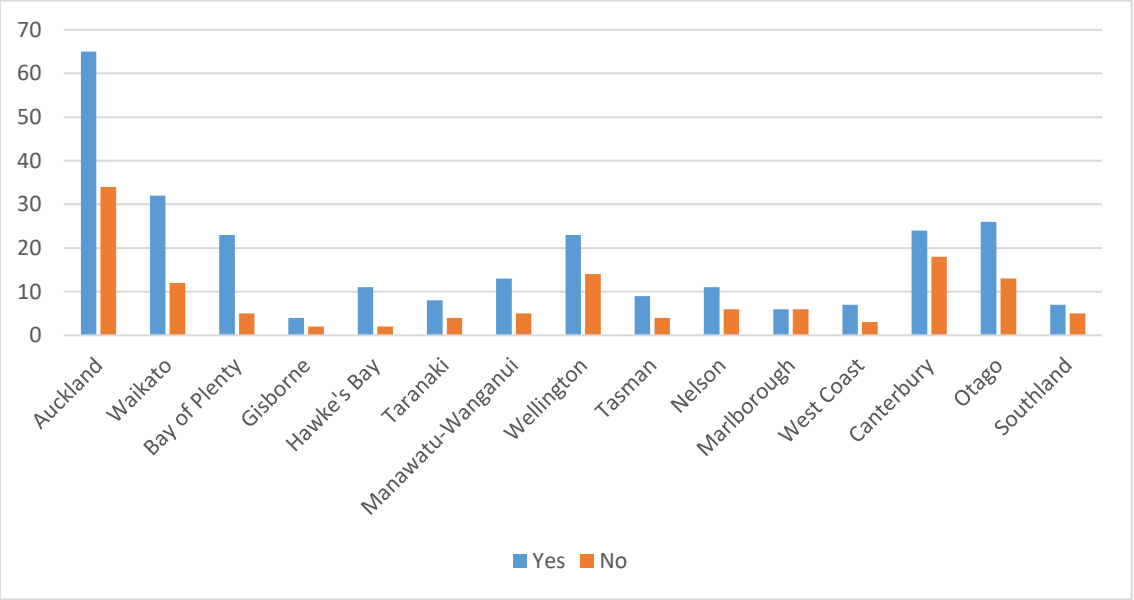

Figure 2. Have you witnessed issues with external water ingress in residential buildings less than 10 years old? Responses per region.

4.2 Housing typologies most affected

Of the 137 survey participants who said that they had witnessed weathertightness issues in new residential builds, stand-alone housing stood out as the typology most affected (Figure 3).

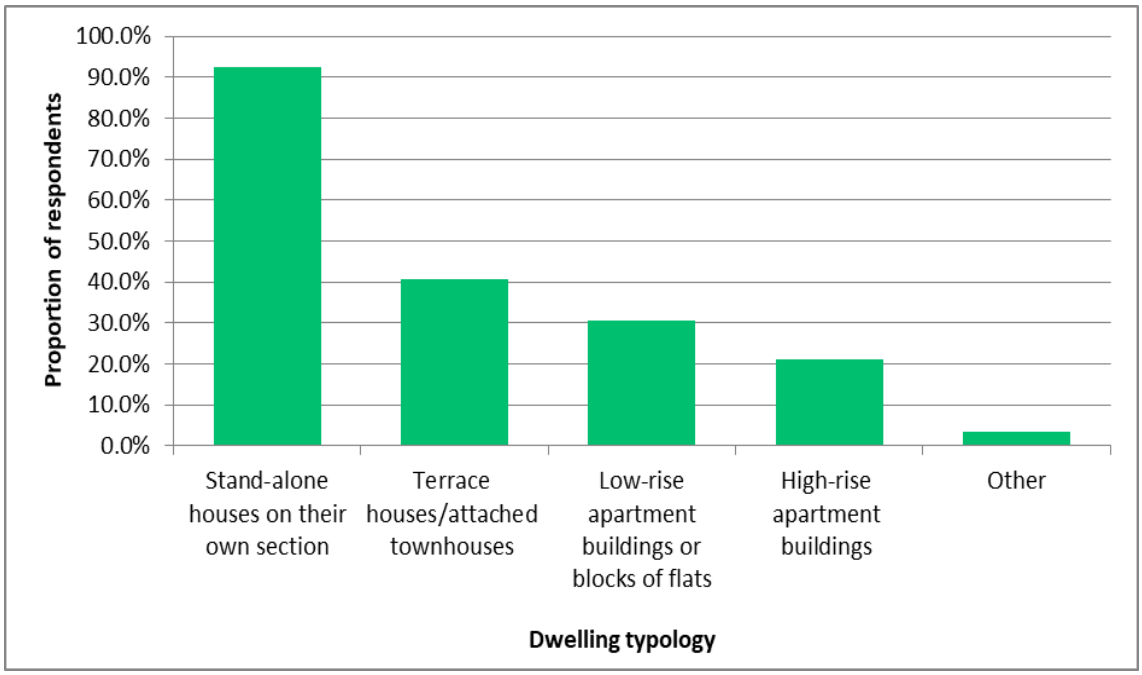

Figure 3. What types of housing did this primarily affect? Multiple choice.

Upon reviewing residential building consent data over the last 3 years (Table 2), these responses likely reflect the fact that detached housing represents the highest proportion of consented dwellings in recent years. Therefore, those surveyed in this study were more likely to see stand-alone houses under construction than other typologies.

Table 2. National building consent data by housing typology.

Quarter	Stand-alone houses	Apartments	Townhouses, flats, units, retirement villas and other dwellings
2017 Q1	4,937	593	1419
2017 Q2	5,217	619	1624
2017 Q3	5,768	1,166	1,764
2017 Q4	5,100	861	2,019
2018 Q1	4,797	760	1,697
2018 Q2	5,511	1,135	2,282
2018 Q3	5,284	1,069	2,033
2018 Q4	5,533	587	2,308
2019 Q1	5,288	1,242	2,244
2019 Q2	5,333	1,212	2,671

More insight into the types of modern housing more prone to external water leaks was obtained via responses to the survey question 'What aspects of the buildings were responsible for water ingress?' (Figure 4).

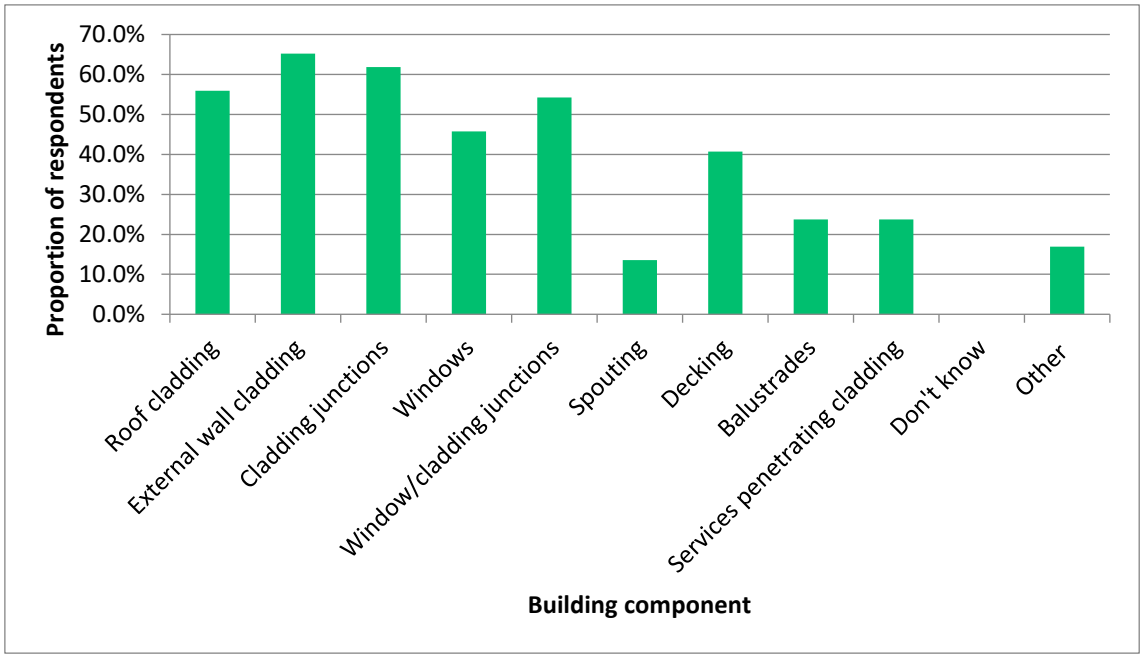

Figure 4. What aspects of the buildings were responsible for water ingress? Multiple choice.

Responses to this question clearly show that industry professionals within our sample largely view external cladding and the junctions between them as the main sources of external water ingress in modern buildings.[7] This may reflect a correlation between the persistence of weathertightness issues in modern homes and consumer preferences for more diverse building aesthetics.

Several survey respondents also selected 'other' and elaborated that, while junctions and a lack of water-deflecting systems such as eaves represent obvious weathertightness problems, so too is a lack of home maintenance, which can undermine the integrity of any residential structure by allowing water to penetrate even the most well built homes.

4.3 Root causes of weathertightness failure: feedback from survey participants

At this stage, our data suggests that it is common for building industry professionals throughout New Zealand to encounter weathertightness issues in residential new builds and that this affects all building typologies, especially those that reflect the modern trend of using multiple cladding types.

What remains in our analysis is an understanding of the reasons why weathertightness failure continues as a problem in the residential sector despite industry attempts to prevent external water ingress following the leaky housing crisis.

[7] Some survey participants provided additional comments explaining their answers to this question. Of these, most noted that structures that are more susceptible to leaking are those whose designs venture beyond that of the traditional single-cladding, single-storey, gable roof properties. A common view was that, as residential buildings have become more complicated, so to have instances of external water leakage.

As demonstrated in Figure 5, there were two top issues when survey participants responded to the question about why weathertightness issues persist in residential construction – inadequate design and incorrect execution of installation specifications.

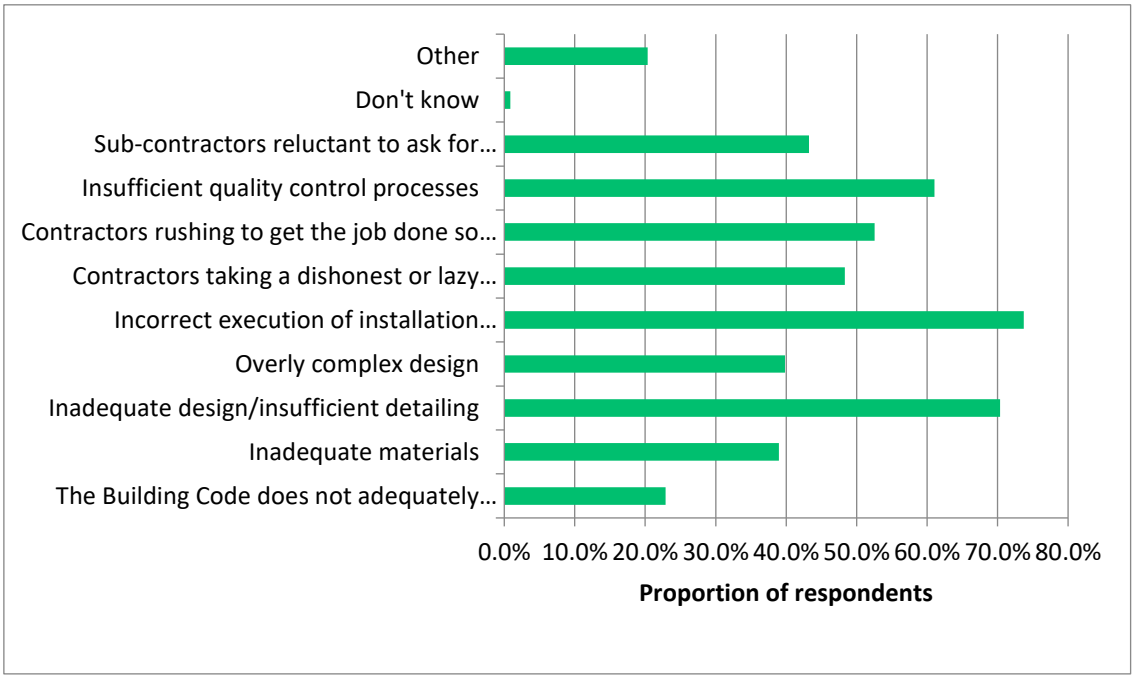

Figure 5. In your opinion, what are the reasons why weathertightness is an ongoing issue in residential construction? Multiple choice.

However, other themes also emerged strongly, including a view that a lack of professionalism amongst contractors contributes towards the problem of weathertightness failure. Here, survey participants cited contractor dishonesty and laziness and hastily trying get the job done as factors behind the issue of external water ingress. In addition, 43% of survey participants who answered this question also mentioned that subcontractors may not ask for help if they are having problems with their work on site. This is potentially compounded by insufficient quality control processes on worksites – a problem indicated by over 60% of survey participants – suggesting that the consequences of a lack of professionalism or capability amongst tradespeople may in some cases go unidentified by on-site management.

'Other' responses within the survey included the view that designers generally design what is required to get building consent, basing their drawings on Acceptable Solutions within the Building Code that represent the bare minimum requirements for deflecting external moisture.

5. Focus groups and interviews

Responses to our survey question on the reasons why weathertightness issues persist in residential construction indicate that it is a multifaceted issue with interdependent causes. This was reinforced by industry feedback obtained via focus groups and personal interviews.

5.1 Operating environment

5.1.1 The impact of consumer price sensitivity on procurement

During focus group and interview discussions, it became clear that weathertightness failure may be reflective of systemic failure within the industry, with multiple issues combining to undermine building quality. For many of those spoken to, this relates to external pressures on the industry, primarily driven by clients' concerns about money.

> Satisfying clients' expectations about money is always an issue around everything. The bottom line is always a fiscal one, isn't it? It's always money. If we had clients that say, 'We care about the money, but we care more about getting a really good product that we feel confident in', and if every build was like that, you wouldn't have weathertightness issues. (Focus group participant, Auckland)

Some study participants noted that consumers' concern about project cost and a common preference for the cheapest builder had created an environment where less-competent builders are successfully undercutting their more experienced and capable competition.

> An inexperienced tradie can get his or her ticket, then go out on their own. They price for a complex project and undercut everyone else as they fail to appreciate the complexity. They then build the home making fundamental errors due to inexperience. (Builder, North Canterbury)

> It's been a race to the bottom. And when you're racing to the bottom, people forget you've always got to make money to stay in business. And so, for me, that's really where some of the procurement issues come in. People think because you're $20,000 dearer than the bottom one, you're ripping the clients off. But the reality is there's quite often a different quality in what you're going to get. (Builder, Palmerston North)

> It just comes back to that ugly thing of cost to clients, so we're dealing with that. Because we in New Zealand have been, and still are generally, price-driven, that if a competitor's not doing something and we are, typically we're pricing ourselves out of the market. (Builder, Tauranga)

> If you see the guy next door to you building in a way that is inferior and he's getting away with it and he's able to sell his house $2,000 cheaper than you are and still make an extra $2,000 in his pocket because he's taken $4,000 of value out of the house, then you're going to look pretty hard at the way you're doing things and you're going to think, well, I'm just a fool here, I'm making good houses and better than they need to be obviously, and that means that the worst builders start to dictate the standard of building. (Engineer, Christchurch)

Instead of focusing solely on the actions of building professionals, these comments acknowledge that building quality is also influenced by external forces, commonly being a price-sensitive consumer market that results in some clients gravitating towards low-cost contractors. According to feedback, this in turn relates to a commonly held misperception within the consumer market about what constitutes value for money, which increases the likelihood of less-experienced cut-price builders winning contracts, setting a trend for other contractors to follow.

5.1.2 Impact of consumer price sensitivity on quality control

Architects were also vocal about the impact of consumer price sensitivity on weathertightness. Feedback from several designers was that, in addition to seeking out the cheapest builder to undertake their work, clients often limit the involvement of architects in an attempt to save money.

> I partly think [that the persistence of weathertightness failure] is because clients in a residential setting sometimes don't choose to commission the architect for full service. The architect is the client's representative on site. So if you really want to hold the quality of your design that you've ticked off with it being built as per those plans, the only assurance you've got is if you've got someone who's on site doing observation for you alongside of the builder. That role is now intermittently used by clients in the residential setting. (Architect, Auckland)

> In my practice, we might only be engaged to getting a complete building consent and then we might not have the scope of work that carries onto observing the job during construction. The percentage of work that is like that from our office is only about 10 or 15%, but the observation is critical. Now I say it should be mandatory. (Architect, Queenstown)

> Clients ask 'Do we have to do site observation?' and I say 'No, you're not required by council or the Building Act', and they reply, 'Cool, OK well that's 50k we can save'. So it's a fairly simple equation I think. (Architect, Auckland)

The point raised here is that, in the current market, cheaper and potentially less-skilled builders have a foothold in the industry, while architects are concurrently less likely to be contractually engaged to protect clients' interests through construction observation. According to industry feedback, this creates a situation where there is a lack of independent oversight of the underskilled segment of the building workforce.

5.1.3 Impact of joint and several liability on architects

Feedback from industry professionals is that the problem of weathertightness failure is compounded by the negative influence of joint and several liability, which is a rule that allows for multiple parties to be held fully liable for an event that has caused the client a fiscal loss, even if one or more of these parties was not the cause of the loss.

During the leaky housing crisis, territorial authorities were in many cases the only party building owners could take legal action against, as the builders and developers involved in the construction of leaky homes often stopped trading or changed their business name to avoid liability (Forbes, 2019). However, during this time period, several architects and builders were also made liable under this rule (Mumford, 2010). The legacy of this, according to some, is a contractual environment that is highly risk-

conscious, incentivising industry stakeholders, and especially architects, to seek ways to avoid getting sued.

> The problem, usually, with getting an architect onto the site are the liabilities generally. The Institute of Architects tell their members that they must not go onto a site unless they have a supervision contract in place because if they don't have a supervision contract and you do something and they've been on the site and something happens around some other place, even if they haven't been to that particular part of the job, they can be held liable because they should have been able to see it. So getting an architect onto a site is actually often difficult for that reason because of the liabilities that they have. (Focus group participant, Auckland)

> There are not a lot of architects on site, it's a diminishing thing. Because the clients just aren't engaging them to be on site. They're not going to volunteer to be on site because then it opens the other can of worms around liability. So if you're not engaged to be on site, your insurance policy won't cover you. So even if someone wants you to come out and have a bit of chat, if you're not engaged to be there, you have no insurance cover. (Architect, Auckland)

Feedback from members of the architectural sector indicated that the extent of concern about the liabilities associated with visiting sites while not under the protection of a full contract is widespread.

> I know how scary it is because we ran a seminar, a couple of seminar sessions on it and we had 800 people here in Auckland turn up, worried about doing observation on site. 'What do I need to do? How do I protect myself? What sort of record keeping do I need to have?' And it's unfortunate but the whole litigation issue was spawning the thought process as opposed to ensuring that the work was done well. (Architect, Auckland)

Based on historical examples of architects being sued under joint and several liability during the leaky homes crisis, this concern appears to be justified. As one architect who had been sued under joint and several liability explained:

> We did documentation for a 12-unit development for a developer. We specified monolithic solid plaster over a drained cavity, it was in the drawings, but the developer changed the specification for cost reasons during construction to triple S with no cavity. It failed and I got sued along with others and had to pay! You know it's a tough lesson in life to learn, but having learned that you go forward with some experience and knowledge that you can help your clients and give them a better product. And part of that is engaging [architects] in full service. (Architect, Auckland)

This provides an example of the risk architects face within the industry where the actions of other parties involved in a project can render them vulnerable to financial penalty. It is therefore understandable that the risk under joint and several liability can act as a disincentive for architects to visit building sites on behalf of their clients if they are not engaged on a full contract.

5.1.4 Impact of joint and several liability on building consent authorities

According to many architects interviewed, fear of liability is also driving negative behaviours within building consent authorities (BCAs) in relation to how they assess consent applications and on-site variations. A common view was that, owing to the risk of liability, architects throughout New Zealand experience that BCAs stick rigidly to Acceptable Solutions within clause E2, even if they are not suitable.

> What I've found is that the council's approach is being driven by the council's insurers not council's building experts. So the risk adversity means that the insurers will say 'Thou shall do it this way' and management are saying to assessors and inspectors 'Just do what the insurers tell us to do'. Insurers have got no background in building, no expertise or knowledge of the process. They're just saying 'if we've got the paperwork to cover us in a legal battle, we're good to go'. And what this means is that the judgement and experience of the building inspector or assessor is being taken out of the equation. So for instance, if I come up with a better detail that solves my specific situation, a good building inspector can use their judgement and say, 'Yes that's OK,' and ticks it off. That can be a better result than saying, 'No you must do exactly as this detail from E2,' which wasn't actually intended for this particular situation but it's the closest. So it's actually the removal of decision-making powers for the individuals directly involved in the project to actually resolve it properly. (Architect, Cambridge)

> Just trying to get anything that's an Alternative Solution detail through some councils is just – you've got a lot of architects banging their heads against a brick wall. I know that they've got a lot of pressure on them from council lawyers to not approve anything that's not an Acceptable Solution because they don't want to get sued. (Architect, Auckland)

This indicates an industry perception that, instead of focusing on the best weathertightness solution, concerns about liability are incentivising BCAs to rigidly assess consent applications according to a set of criteria that in some cases may be unsuitable. These comments indicate a belief that some BCAs prioritise their protection from liability above building performance.

One architect suggested that people within his profession are accordingly forced to detail in a way that prioritises the needs of BCAs over that of builders and clients.

> Councils have become more risk averse and as a result of that more following a tick box exercise of having paperwork to cover their butt. I'm now doing my drawings for the building consent officer, not the builder. And I'm doing my drawings to help the consent officer tick a box because that is how they're working through the jobs, and if I don't help them tick their box, I don't get my building consent and that's what I'm paid to do. And as a result, I'm providing them with just the information they need and dealing with questions as they arise from the consent officer, and it's not my focus any more to worry about what the builder's thinking because it's just so damn hard and complicated to get the building consent through. So that's my singular focus in providing the drawings. And so, where I can, I cut and paste a detail out of the Building Code that is close enough to the situation that will get the tick. But if I try to modify the design, modify that detail to even better suit my specific situation and it's

> slightly different from what's in the Building Code, then I have a problem with the council person not being able to tick their box. So I am actually doing less job-specific detailing than I used to although buildings continue to get more complicated. (Architect, Cambridge)

These comments reflect a perception that designers operate within the bounds of a risk-averse regime that paradoxically prevents them from employing what they believe are the best weathertight design solutions.

5.2 Design quality

5.2.1 Skills and education

While some study participants maintain that BCAs' strict adherence to Acceptable Solutions within the Building Code has created conditions that limit the ability of architects to ensure residential weathertightness, another view was that the architectural profession is itself to blame because design standards within the sector often favour building aesthetics over functionality. According to some, this relates to a lack of basic building knowledge amongst some designers.

> I would say one area [for architectural training] that does need improvement is on-site [experience]. There's not enough on-site [experience] in the 5-year architecture programme to really see these issues in practice. We've run a few student programmes that we've taken students to various suppliers and shown them the detailing of a window with various products, and it's been a bit of a lightbulb moment for many of them. Many [architectural] practices will tell you that, because of the advanced computer technology and product libraries that exist, students are not appreciating how you would practically construct something. It's that questioning and inquiry around how would I build this? And it's one thing to design and iterate in the technology environment, it's another to go 'Well how practical is this to actually physically build. and what's the smart way to build this?' I think that's one area where the education environment could improve, and that's feedback from practices but also on observation that you may go through a 5-year architecture degree programme and not go on site once. (Architect, Auckland)

This concern was reflected among the views of employers of architectural graduates.

> I have employed some new graduates. One of them was spectacular, was supposedly one of the youngest and brightest ever to come out of the architecture schools, and she actually did not know that water ran downhill under the influence of gravity. I thought she was having a big piss take, but it actually proved to be true. She actually did not know that. So I mean she was trying to design a roof and didn't actually know how water ran, so somewhere along the line, there was something missing from her education. (Architect, Auckland)

> Graduate architects are hopeless at detailing. The schools of architecture are away with the fairies and do not ground students in how tradesmen work and how good their skills are. They cannot detail anything and know little of most materials, except the fancy 'glitzy' trendy stuff – 5 years at college learning how to used 3D CAD but they have very limited practical skills. (Architect, Rotorua)

According to others, this problem is exacerbated by the fact that increasingly few architectural firms are being engaged by their clients to conduct site observation. The belief is that this divorces some designers' theoretical knowledge about construction from its practical application.

> The only way you're going to get site exposure is in the workplace if you get taken out. But then if you're a residential architect and your firm doesn't get engaged for site observation, then you're never going to see it. So a lot of intermediate members and practices have no idea what they're actually drawing. They've never seen a window junction or a slab junction. They don't understand what the lines that they're drawing on a page really means. So without actually understanding the material and the methodology of how the builder is going to put something together, without understanding that, then it's hard to draw something that's going to work. (Architect, Auckland)

> We're given the plans from the architect. That's what we're stuck to work with, and when we have an issue and go back to them, half the time they can't give us an answer and they tell us to design something and send a picture back to them so they can sign it off to the council, which pisses me off because they're getting paid $150 or whatever it is an hour to do their job and they can't bloody do it. So there should be a minimum requirement that they've got to have 2 or 3 years on trade to understand how the building system works. (Builder, Kaiapoi)

These comments appear to reflect a common belief within the industry that a lack of practical building knowledge can make it difficult for architects to understand what information builders need to turn design concepts into reality. With limited time on site, feedback suggests that some architects lack knowledge of how builders work and the level of detail they require to complete work to a standard that ensures weathertightness.

5.2.2 Accessibility of information

While several architects that were interviewed agreed that a lack of exposure to on-site environments can undermine design quality, one architect who held a senior representative position within the industry felt that there were also information barriers for architects who are actively seeking to learn and upskill. This was especially so with finding information on industry-endorsed Alternative Solutions.

> I do a lot of peer review with architects and good architects too, but there's certain areas where they just actually don't even know where to start when coming up with a solution. They shouldn't have to reinvent the wheel because even when we talk about complex junctions, they're all things that have been done before and there's solutions to them. But they're not published solutions and they're not anywhere that you can go online and find them. (Architect, Auckland)

This comment reflects concern that information about how to detail for aspects of modern residential buildings that sit outside guidance offered in E2/AS1 is not easily accessible for architects. This may make it challenging for architects to find and apply Alternative Solutions that have been proven to work.

5.3 Builders and subcontractors

5.3.1 Poor execution of installation specifications

Survey responses were clear that poor execution of installation specifications is a common reason why some new residential dwellings leak. From direct discussions with industry professionals, this seemed linked to the fact that there is a market for builders who lack the proficiency of their more professional contemporaries and who rely on ways of working born more from habit than from keeping up with industry standards.

> Often we see claddings and junctions installed incorrectly. Builders can be lazy and not keep up with installation updates in the industry. They often have a mindset of 'I've installed it this way for 20 years, why would I change now?' (Architectural designer, Cambridge)

> If they've never used a product before, then I don't think it's an issue. But if they're building six or seven houses a year and they're commonly using a material like weatherboard and they commonly use this building underlay, then they probably never think about it, they just do it the way they've always done it. And then they just teach their apprentice to do it the same way. I doubt they'd ever really go back and look at technical specs. (Architect, Auckland)

Prevalent in these responses is a concern not only with the skills and abilities of some contractors but more broadly with their attitude. While some contractors understandably come into the industry short of experience and know-how, others who have worked in the industry for longer are sometimes seen to resist changing incorrect or ineffective practices. However, according to two builders spoken to, a broader problem associated with installation is that builders often do not have the time to fully review product installation specifications or any educational material issued by industry bodies such as BRANZ.

> Because builders have time constraints, they probably don't sit down and look at the specifications properly, and then the other thing is they'll get half way through a job and realise they're out of their depth but it's too bloody late so they just slap it on and cover it up hoping like hell that no one's going to catch them out, which inevitably over time does happen. (Builder, Palmerston North)

> You look at your average person on the coalface, at the frontline of the construction industry, they see themselves as overworked, underpaid and short of time to spend with their family. They don't want to sit down reading endless articles and educating themselves. (Builder, Porirua)

Some interviewees felt that the sheer amount of specification information that builders are supposed to read discourages them further, making it more likely that they will rely on their intuition about how products should be installed.

> I was on a job yesterday and the specs had 1,160 pages! So if you take your average Licensed Building Practitioner, they're not going to read that documentation and they shouldn't be expected to read that documentation. Even if a set of working drawings stretched to 50 pages, I would be pretty confident that most people on site are only reading five of them. (Builder, Porirua)

> There is a lot of stuff in the specs that is just unnecessary for builders to read. You don't want to confuse people. Builders end up with specifications that are several hundred pages long, and that's even more discouragement for him not to read it. (Architect, Cambridge)

> This is one of my bugbears when I do reviews. You know I'll have architects saying 'I don't need to draw, it's in the technical spec'. I was like 'Yeah, well how's the builder going to know where to find that in 500 pages. Can't you just stick it on the drawing in plain sight where you can't miss it?' (Architect, Auckland)

According to one builder, some builders struggle with literacy and are simply overwhelmed by the amount of specifications they receive and are forced to rely on their own understanding on how products should be installed.

> A lot of apprentices that are coming through are illiterate or can only manage at a low level of reading, so to get them to read through specs and details for them is a real challenge, often relying on memory of how they installed it last time. (Builder, New Plymouth)

These comments suggest that, while there are issues with installation competency within the industry, the industry has also created conditions enabling poor-quality workmanship. For time-short building contractors struggling with low levels of literacy and winning jobs that may be beyond their skill level, there may only be enough time to cast voluminous installation specifications a quick glance before they get on with the job. Accordingly, it is debatable whether all issues with installation can be explained by contractor skill level and honesty or by the market conditions that result in time-poor contractors winning contracts that exceed their level of technical ability.

5.4 Quality assurance

5.4.1 Effectiveness of the LBP Scheme

As earlier noted, the LBP Scheme was introduced as one response to the leaky housing crisis and intended to differentiate between skilled licensed builders and their self-taught counterparts who have historically been at the centre of New Zealand's DIY building culture. The scheme was phased in to introduce greater accountability amongst builders and to set a standard for skill, professionalism and capability. However, despite the government's intention for this scheme, industry feedback is that it has been largely ineffective in holding underperforming building practitioners to account.

> You don't even have to be a qualified builder [to join the scheme], so to me it's wrong before it starts. If they're trying to clean the building industry up, surely those that are going to be licensed need to be qualified. So I just find it's unfair when you've got someone like myself, all the people that work for me are qualified and then I can go down the road to another gang where no one's qualified throughout the whole gang but they're licensed building practitioners so they've got the same rights as what I have. (Builder, Palmerston North)

> To be honest, the licensed building practitioners' regime has not made a scrap of difference. That was meant to bring in people who could be reliable and so on and it hasn't. What it's done is just give a licence to a hell of a lot of people, a lot of whom aren't tradesmen. (Engineer, Christchurch)

Although devised to raise industry standards, a common view was that the scheme has not yet met its objectives. While there was acknowledgement amongst interviewees and focus group participants that there are many excellent builders who are licensed, there was also widespread belief that there are many low-skilled and dishonest building practitioners who have met the licensing criteria and are still getting away with substandard work.

5.4.2 On-site supervision

Consistent with survey feedback, for some study participants, compounding problems with quality assurance is that site supervision of subcontractors is also lacking. The main concern here is with inadequate LBP oversight of low-skilled labour.

> There's a reasonable number of bad labourers that are sometimes left to get on with the job on their own. There's some pretty dishonest work sometimes. In [the] years when I first started work, there was always a foreman or the builder himself on site, and he watched things like a hawk. Now, when people are left on their own, if they are of a dishonest bent or want to take a shortcut, it's pretty easy. Instead of a foreman, you get someone in an office just ringing up subcontractors all day or every day, and they all just do their own thing and no one's keeping an eye on things. And of course, the building inspector and people like myself that are doing inspections, we're only appearing when we're invited so of course everything's going to look hunky dory when we get there. (Engineer, Christchurch)

> As an LBP, we have an obligation to ensure we have quality control on site. While I don't do a lot of sitework, I'm on my sites every day monitoring the quality, but a lot of them don't do that. A lot of them might only go on site once a week. The project can go a long way in that week, and you miss a lot of perhaps critical information or critical oversight. (Builder, Palmerston North)

Concerns about quality assurance also extended to the belief that BCAs' own inspection regimes can provide clients with false confidence that issues will be picked up on site.

> There's a very broad impression within the New Zealand public that council are a proxy for a clerk of works on site. And they simply are not, they cannot be, they don't have the resources to be so, and if they were so, council consent fees would triple. You know, a typical council inspector would be on site on a house build for maybe 6–8 hours maximum. For a clerk of works to be on site on a house build, he would be there for 1,000 hours. You cannot expect the building inspection regime by council to be a substitute for a clerk of works. Buildings are too complex and have too many layers. There are many more processes and things that happen on site that require oversight, and they don't have the resource to do it. (Architect, Auckland)

These comments suggest a belief that quality assurance within New Zealand's building industry is lacking and should be strengthened if issues such as weathertightness failure are to be prevented. Given industry feedback that architects are now less commonly engaged to act in a construction observation role and council inspectors only occasionally visit sites to review highline issues, this appears to create an environment where low-skilled, time-pressured or dishonest contractors are more likely to get away with work that undermines the water-deflecting ability of building exteriors.

6. Industry-recommended solutions

6.1 Survey feedback

So far, our research suggests that numerous factors underlie the persistence of weathertightness issues in New Zealand, including:

- client price sensitivity
- joint and several liability
- variable level of skill among some builders and designers
- a lack of accessible information for designers and builders
- an LBP Scheme that some believe has failed to raise building standards
- insufficient on-site supervision.

Unsurprisingly, when industry feedback was sought regarding potential solutions to the persistence of weathertightness issues, recommendations were diverse and largely aimed at addressing what research participants felt were the interrelated and multitudinous causes of the problem.

Feedback on how to address the persistence of weathertightness issues was first captured via the online survey, where 10 potential solutions were presented to participants. Participants could select as many options as they thought applied or could alternatively suggest other solutions. Additionally, participants were given the option to signal that they did not know of any solutions. The results are shown in Figure 6.

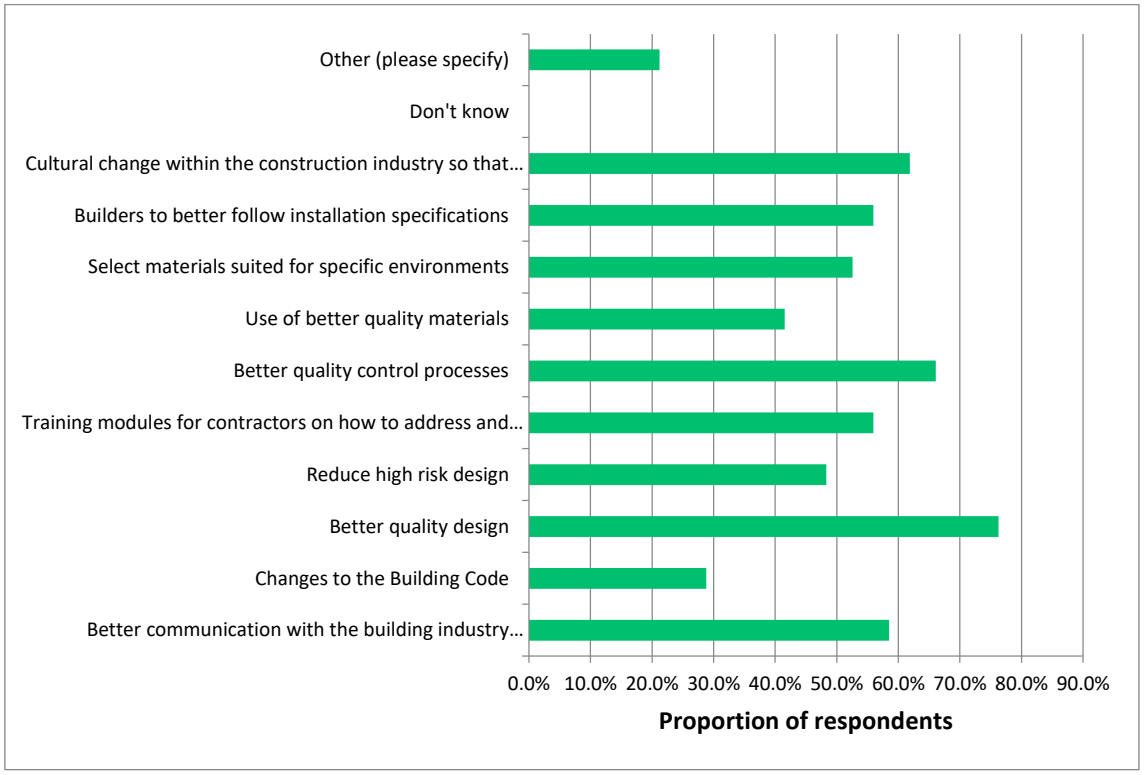

Figure 6. How should weathertightness issues in residential construction be addressed? Multiple choice.

Out of the 10 presented options, all were indicated by survey participants to be potential answers to address weathertightness issues. Better-quality design, better-

quality control processes and cultural change within the construction industry gained the most responses (76%, 66% and 61% of survey participants, respectively).

Adding to this, 25 participants specified other solutions that were not listed –12 participants identified a need for improved training and education for both builders and architects. This was suggested through reinstating the 4-year apprenticeship scheme, improving the regulation of training and requiring further qualifications in weathertightness for industry members. Comments by seven participants also suggested a need for improved detailing of plans, indicating that they often lacked consideration of weathertightness factors such as wind-driven rain. Other comments cited a need for improved liability schemes, information and understanding of compatible materials.

This data provides insight into industry views on how to address weathertightness issues within New Zealand homes. To further gauge industry opinion on how to mitigate weathertightness failure, the topic was broached during the focus groups and semi-structured interviews. For simplicity, data obtained from these interviews has been summarised into five key themes encompassing the industry's operating environment, design, Building Code, builders and communication of solutions.

6.2 Operating environment

6.2.1 Educating clients about procurement

A broad perception amongst industry representatives was that clients are largely misguided in their understanding of what constitutes value for money when negotiating construction and consultant contracts, often prioritising contract value over building quality and performance. As discussed, one consequence of this is that few architects are engaged by their clients past the submission of consent applications, excluding construction observation as a means of quality control from their contracts. There was a strong view amongst design professionals involved in the study that this attempt to save money is foolhardy and that, to ensure building quality, clients need to seriously consider the value of paying for construction observation by an appointed representative.

> There are some [contractors] who are trying to push the boundaries of course, and they sometimes don't care about regulation, so that does require somebody at a high level keeping an eye on everything. (Focus group participant, Hamilton)

> Many clients will employ architects up to a certain point and they may take the design and get draughtsmen to complete the documentation to the end. They may get the architect to get the building consent and then completely cut the architect's involvement altogether. If an architect is engaged in full service from start to finish, I would argue that the risk of building failure is reduced as they will be available at all times consistently throughout the contract. (Architect, Auckland)

Although the importance of regular quality checks by a client representative was stressed by many people we spoke to, it was not universally agreed that this needed to be solely performed by an architect. Indeed, much of the feedback focused on the need to again make the clerk of works position commonplace within the construction industry. Traditionally, a clerk of works acts as a site inspector on behalf of the client, reporting to them their findings on workmanship and building integrity. It was broadly

felt that reintroducing this role to construction sites would raise building standards and accountability.

> How you stop [weathertightness issues] straight away is you have some expert tradesperson who's got a bloody big whip and he walks around the site and says 'No, that's wrong, do it again.' That used to be the clerk of works. (Focus group participant, Hamilton)

> Some architects tend to only visit site once a month. If you're going on site once a month and you see something wrong and you say 'Actually, you have to redo that', potentially you're telling them to take back 3 or 4 weeks' work and you've got a deadline trying to get 4 or 5 months out and there's the cost of that. It doesn't work. So I think if you have people reviewing work or an architect's been engaged to do that or whoever, they need to have the ability to be doing that relatively regularly and fees to cover that, so that if something needs to be redone, it is done quickly. A pretty easy solution to this would be to engage a clerk of works. (Focus group participant, Hamilton)

This feedback indicates that there may be value to clients procuring an independent consultant to undertake construction observation. With the clerk of works position becoming less commonplace and clients being less inclined to engage architects on a full-service contract owing to a desire to reduce total project cost, there was broad concern amongst research subjects that clients are becoming increasingly vulnerable to the consequences of poor workmanship. Accordingly, there was a widespread belief in the importance of clients better understanding the benefits of procuring the services of an independent quality assurer to catch issues with the build as soon as possible before they become a larger problem.

6.2.2 Proportional liability

As raised earlier, there was a common belief amongst research participants that the introduction of joint and several liability had created a culture of risk aversion and a fear of being sued. It was held that this had led to a reluctance of architects to attend site if not contractually obliged and has resulted in an unwillingness amongst BCAs to accept designs that did not strictly adhere to the Acceptable Solutions laid out by the Building Code.

To address this, feedback from industry suggests that proportional liability, similar to that introduced in some Australian territories (McNair, 2016), should be introduced. As opposed to joint and several liability where any one party can be held 100% liable for any leaky home damage, proportional liability proposes that parties are held liable in proportion to their fault in the damage as determined through a judicial process.[8]

The widespread fear of liability within the building industry was raised by one architect as being an impediment to building quality in New Zealand and the cause of a 'last man standing' mentality where risk is ultimately owned by the last party willing to remain in business.

> [Builders are] happy to take responsibility for it because we're wanting a good job, we're wanting it completed, but we're not allowed to take responsibility for it. And it comes back to the issue of proportional liability where, at the moment

[8] Issues around contractor risk and liability are presently being reviewed as part of the government's Building System Legislative Reform Programme (MBIE, 2019).

> with joint and several liability, the last man standing is the council. That risk aversity is actually creating risk. (Architect, Hamilton)

Industry feedback suggests the alternative scheme must be proportional liability in order to minimise the risk of faulty design or workmanship to other parties. One architect explained that proportional liability would allow for a decrease in time pressure for industry members and faster approval of Alternative Solutions.

> It's really got to be proportional liability so that the councils aren't under the fear and risk of their regime that they are currently under, so that they can accept some other experts certifying and take a risk of that away from the council. And then they can approve things much quicker and the whole timeframe issue, that pressure that's in the industry is removed, and the whole process flows quicker, and when there are problems instead of everyone running for cover, you can get solutions approved quickly. (Architect, Waikato)

According to these research participants, the paradox of joint and several liability is that it inadvertently intensifies risk in the building industry in an attempt to reduce it. Because of the fear associated with being made liable for someone else's mistakes, industry professionals are incentivised to minimise their own risk exposure. This may be through refusing to visit construction sites (as in the case of some architects not engaged on a full contract), by BCAs refusing to sign off Alternative Solutions or by industry professionals deciding to opt out of the industry altogether, leaving others to shoulder the burden of responsibility associated with building failure. Feedback from those we spoke to reflects confidence that implementation of proportional liability will not only reduce this risk but is likely to result in professionals taking greater responsibility for their work.

6.3 Design

6.3.1 Improving the skills and education of architects

To tackle a perceived lack of knowledge amongst architects about how buildings are constructed, some research participants promoted on-site experience and observation as being fundamental to designers' education. It was recognised that, once designers had gained on-site experience, they will be better able to pair their gained technical knowledge with their existing design skills.

> As a designer, you learn a lot more [when going on site] because you're going 'Oh, yeah, the builder can't actually build these things'. So I've drawn up a nice pretty picture but when you look at building it you go 'Oh, we've actually put a backflashing in the wrong place', and if that leaks up to a point it causes water ingress into the structure. (Focus group participant, Auckland)

> You understand what it looks like to a builder. You understand what it actually feels like to be standing in front of a particular piece of construction and to know what it feels like to implement that thing. I don't know how you get that experience to designers who have never been [on site]. (Focus group participant, Auckland)

Some building professionals within the study indicated that on-site experience should be gained during schooling, which they believe is a gap in the current education system.

> It should be taught on site. [Architect trainees] should be on site. If they don't see the site, [their knowledge] is just based on their computer. (Focus group participant, Auckland)

This was not the only inadequacy identified with architecture training. Industry feedback also revealed strong opinions that weathertightness training should be a more integral component of the curriculum in architecture schools.

> There definitely is a fundamental lack of detailed understanding of how solutions are implemented on a job site. I employ an architecture graduate, she has a master's degree in architecture. I employed her as a draughty. She's a really flash draughtsperson, but she has no idea how you would build anything. She would be producing drawings that have no real relationship or understanding of how those drawings would relate to actually building something. If they have to do work experience for a year, they get a log book and they go out there, even if you can just get somebody to say 'Look, you can come onto my job 1 hour a day for the next year and we'll show you what we're doing'. And if that had happened, there's a whole lot of explaining that I wouldn't have had to have done. (Focus group participant, Auckland)

Other participants acknowledged how designer training was lacking in relation to the design of complex details such as those that involve multiple junctions. This led one participant to believe that Alternative Solutions should instead be drawn by a technician instead of an architect due to the current insufficient training of designers.

> Where [designers] seem to come unstuck are the complex 3D details and penetrations, which designers shy away from detailing with because they are too hard. Designers need training in how to detail the hard stuff, because if they don't, who will? The builder? (Architect, Auckland)

One architect was particularly passionate about improving training for architects, suggesting an elaborate new educational approach to lift design standards across the board to ensure all new architects develop practical building knowledge, again involving on-site experience during training.

> All budding architects and techies should attend a polytech to undertake a 3-year draughting and technical construction detailing course plus 1 year's experience in an office. At least 6 months of this course should include hands-on experience with each trade. At the end of the course, graduates get a degree in building technology, which gives them the right to attend a school of architecture or they can become a draughty and/or LBP or move to an allied profession such as project management, building inspector, etc. (Architect, Rotorua)

Industry feedback indicates that there is a deficit of understanding amongst architect graduates around the practical application of their designs and the detailing of difficult build elements. Most feedback indicated that on-site experience and observation would bridge this deficit and should be incorporated into the design school curriculum. It was further suggested that incorporation of on-site work experience would allow for this understanding. Without reform to taught skills, it was felt that some architects will continue to design faulty buildings, thus relying on builders and inspectors to identify their mistakes.

6.3.2 Consulting builders during design

In addition to ensuring cohesion between the information needs of builders and the design skills of architects, it was commented that weathertightness issues could be avoided if builders were better consulted during the design phase. Similar to what on-site experience and observation for architecture students would aim to achieve, some study participants maintained this would allow for practical building knowledge to be better incorporated into design during a project's prebuild phase. It was believed that this early consultation would result in prompt identification of potential design issues, reducing the amount of variations required later on site.

> It's always good to resolve design issues before the design leaves the office. What I've seen is if the design is unresolved and leaves the office, it goes into the council and it gets stamped as they don't pick up on junctions usually. Then, it goes out and there's a whole bunch of issues. So initially, when you spend more time during that phase of documentation, you can resolve all the design issues. (Focus group participant, Auckland)

> If the builder was employed earlier at the start, before the design process, then you can go back and you can work with the designer and solve a lot of those issues all the way through. (Focus group participant, Auckland)

Consultation with builders was further expressed as valuable to architects as they could understand where their designs caused issue and needed improving.

> From a design point of view, you'd like to have a chance to pick that up, so when you have a conversation, the builder may say 'Well, this is different to the detail you've drawn, how are we going to do it?' But often that never happens. (Focus group participant, Auckland)

Not only was early consultation with builders expressed to be imperative for the prevention of weathertightness failure, it was also suggested to pave a way for a relationship to form between the architect and builder – a factor identified to be important for on-site productivity and quality assurance.

> We obviously need to form a relationship with the designer, because if we're not comfortable about that detail, we're the one that takes the responsibility. I think it's that interface with the design team ensuring that it is done properly and it's not going to fail. (Focus group participant, Auckland)

> We have two or three designers that we want to work with because we know as soon as we have a query – I'll send them a photo of the building or this joint – next morning, there's another variation there and we keep moving. But unless you can have that communication with the team in general, unless you have that, man it's hard work. (Focus group participant, Auckland)

> Once you get that interaction on site, things go a lot better, builders start asking the queries that they should be asking, which helps a lot. I think that sort of relationship with the builders on site is quite key. (Focus group participant, Auckland)

Through introducing a builder's perspective to design prior to construction, industry feedback suggests that many weathertightness issues can be identified early and can therefore be avoided.

6.3.3 Increasing the use of 3D drawings

To further improve the communication of design between builders and architects, the use of 3D design was recommended. Several study participants maintained that this is essential in order to improve architects' understanding of how their designs will appear to builders and to enhance the detailing of complicated features.

> We need more 3D details of corners and junctions. Too many details are simple 2D sections. What happens at the intersections? (Architect, Cambridge)

In addition to aiding communication between contractors, one builder expressed that implementation of 3D design was essential for a client's understanding of their layout as they do not always possess the skills learned by architects and builders to convert 2D drawings into three-dimensional space.

> You go to a client, they've given you the drawings and you've agreed on a price and you've been through it a half a dozen times and then you're starting to build it and they say 'I didn't realise this room was so small' or 'I didn't think that there was a wall here' or 'This cupboard is too shallow', and you say 'Well, it's here' and they say, 'I don't know what that feels like'. Most people can't elevate a set of two-dimensional drawings into three dimensions and you have that sense of what it actually feels like to be in it. (Focus group participant, Auckland)

Use of 3D design was suggested to be an effective solution in enabling the understanding between contractors regarding the design and detailing of complex build features. Better utilisation of 3D design was indicated as a valuable means to improve weathertightness through facilitating this conversation so that both parties were 'on the same page' when it came to the structure of the build. Furthermore, it was maintained that 3D design would allow for clients to fully comprehend the dimensions of their desired space, resulting in fewer variations required during construction.

6.4 The Building Code

6.4.1 Upgrading E2/AS1

Reflecting survey feedback, few comments obtained via focus groups and interviews with industry representatives suggested that the Building Code is deficient. Indeed, most industry professionals spoken to agreed that E2/AS1 was good in its present form as it acts as a simple guide to minimum weathertightness requirements.

> E2 provides a really good guideline for most solutions … you can't cover everything, I mean the Bible doesn't cover everything from a moral point of view does it? So it gives a really good look at how you would find a solution to a particular problem given that generally this is how you should be thinking about it. It's a very good generalised first step. (Focus group participant, Auckland)

> E2 really is, for us at the design end, it's a really good first look at how you would start to think about how you design a junction. Just basic stuff like clearances, cladding clearances and things like that, that if you're going to have a document that just did that generalised first good look at something, that will give you a good foundation for continuing to design for specific claddings, specific junctions. E2's good. (Focus group participant, Auckland)

However, a small number of people disagreed with this, noting that E2/AS1 provides an insufficient number of weathertightness Acceptable Solutions because BCAs are typically hesitant about approving Alternative Solutions.

> [For] some of the tricky areas, it would be nice to have more solutions because the alternative is a brilliant idea in theory but it's just too tricky and time consuming to do it. If you go to go for a Building Consent with an Alternative Solution, you're not sure how long it's going to take to get through. So on a time constraint, you generally rule it out, you have to. But if you had a series of options that you could draw on that might be better suited to your situation, that's going to help everyone. (Focus group participant, Auckland)

> The problem is that there is typically only one detail for each of the general situations. Having more pre-approved details has got to be good. There's a lot of gutter situations and roof junction situations and particularly corners where you typically detail a two-dimensional cross-section on a flat base. The problem areas are where you've got a floating roof hitting a corner and the 3D detail around that and there's all sorts of different claddings and roof slopes, and what if there's two different roofs hitting at that point and other things? If there were 10 kinds as many details [in the Building Code], best-practice stuff that we could use either cut and paste or say to the building inspector 'This is the closest one to our situation and we've modified it slightly', that would be the solution. (Architect, Cambridge)

For one architect, E2/AS1 is simply irrelevant to some higher-rise buildings and consequently needs updating to include more solutions to reflect the industry's trend towards intensified living.

> E2/AS1 is a fairly comprehensive document for a limited range of building types, and once you get up into multi-storey, AS1 runs out of puff at about four or five storeys. After that, you're into Alternative Solutions. I think that the construction industry and the BCAs are completely obsessed with it, Acceptable Solutions. The Building Code allows for Alternative Solutions on any part of the Code and in any part of the building to be input forward. Generally, it's almost universal, BCAs will reject Alternative Solutions where they can because they don't have the technical skills within their own organisation to assess them properly. So once you move away from AS1 and come out with your own solutions for E2 ,you're going back to first principles and I think that's where [BCAs] do have a lack of training and understanding about what first principles are regarding keeping water out of buildings. E2/AS1 is a standard 'go to' book of ready-made solutions that don't require people to understand first principles, and that's potentially where the whole construction industry does lack knowledge and education. (Architect, Auckland)

As these comments show, although E2/AS1 is held by most within the study as a sufficient basic guide to ensuring weathertightness, others hold the view that its efficacy is undermined by BCAs' reluctance to approve Alternative Solutions, causing reliance on a limited range of Acceptable Solutions that are not suitable for all building scenarios. Failing a change in how BCAs assess Alternative Solutions, some accordingly believe that E2/AS1 should be expanded to include more acceptable design options.

6.5 Builders

6.5.1 Reforming the LBP Scheme

Industry feedback indicates widespread belief that the LBP Scheme needs reform in order to better ensure Code compliance, raise overall building quality and guarantee that industry members are accountable for their work.

To improve Code compliance and minimise issues such as weathertightness failure, it was firstly identified that the government needed to revise who should be an LBP.

> I feel that the industry needs a movement change with the LBP licensing system. We have the bones of a great idea, but it should be compulsory to be an LBP, not optional. If you want to build residential, whether you are a labourer, apprentice or qualified, you should be an LBP. (Builder, Taranaki)

Some industry professionals further identified a need for greater cohesion and collaboration amongst LBPs. This was proposed through an annual educational seminar or course that allowed for the networking and enhanced education of LBP members.

> Perhaps every LBP has to do a 1-day course per year and highlight critical issues or something like that. The LBP Scheme currently doesn't bring the builders together. (Focus group participant, Auckland)

> We've got to sit down and have a beer and talk about issues because we all have the same issues. Perhaps a lot of the younger guys now wouldn't do that because they don't trust their next-door neighbour. If they're going to go into business, they need to do some business development courses, that's something that could be taught. (Builder, Palmerston North)

Further emphasis on the importance of LBP reform was indicated by one builder to include education and certification within the industry. It was suggested that there needs to be better training of complex skills under the LBP Scheme to ensure quality workmanship and improved Code compliance.

> There needs to be a compulsory block course every 6 months getting trained on whatever BRANZ see in the industry as an issue at that time. One aspect is you could do training on complex junctions, and this could be a separate licence over and above a qualified builder, you can't do complex junctions unless qualified. Block courses could be 3 days or 1 week every 6 months and have to be completed to keep your licence with a fail aspect and a chance to sit the course again. This will let us weed out some of these people that should not be in the industry. (Builder, Taranaki)

During our research, there was a clear appetite within the industry for greater accountability amongst LBPs. Feedback indicated that, unless reform occurred, reliance on councils to identify weathertightness issues within new builds would remain. It was also indicated that some industry professionals are apprehensive to register as an LBP as it involves acquiring direct responsibility of their work.

> I don't think it's going to change unless you change that scheme and [increase] accountability and not rely on the council who's the last man standing to pick up the tab. There has to be a change in the industry to make sure that the building they're building is for a lifetime, not for the next 10 years. (Focus group participant, Auckland)

> LBP kind of does different things to different builders. It makes some of them scared, it makes some of them excited and empowers some of them. Everyone's still a bit freaked out by it or a lot of people are anyway, whereas I'm like 'Hold on a minute, this is a good thing, this can empower you to own what you're doing and deliver a great building', and they're like 'Oh, I don't know if I want to own it' … Some of them are concerned about owning the potential problem that they can't see. (Focus group participant, Auckland)

> Several of our employees said they were really concerned because they thought they were going to end up in court. And I said 'No, you're a good-quality carpenter, this is your job, you just carry on doing it', and obviously there's a bit of education going through as you go to ensure they can do it properly and that they're competent. But they're all fine now, but I think earlier on in the bit they were concerned because you could end up like in front of the LBP Board and get smacked on the hand or whatever. (Focus group participant, Auckland)

Feedback also suggested a need for an improved complaint system for LBP members to hold them accountable for substandard work. It was implied that submitting complaints against members was problematic as industry members were unlikely to lodge complaints despite observing clear violations by others.

> As an LBP, it's your scheme and it's your responsibility to enforce it. If an LBP designer finds a builder and the LBP builder is not doing his job properly, he should actually be lodging a formal complaint … but you would never see a builder lodging a formal complaint against a designer, and I've only ever heard of one designer lodging a formal complaint against a builder for not following his plans. (Focus group participant, Auckland)

According to this individual, the current LBP complaint system is weak and underutilised. To counter this, some suggested implementing an improved points system to effectively hold members of the scheme equally accountable. Some research participants proposed a punishment and reward system for members when considering inspections.

> There should be a more accessible complaint system, and if you have a complaint against you, you accumulate points, and if you gain too many points you need to appear in front of the committee and they can have a look at your work. I don't think there's enough accountability. (Focus group participant, Auckland)

> If you had someone that failed, say, three inspections in a month, they should be scrubbed off the list because obviously they don't care. Whereas someone that might fail one inspection a year, they're obviously very tidy in what they're doing and should be rewarded for it in one way or another. So if you had that reward type aspect into it, you'd find that everyone would actually tidy their act up a wee bit and would be looking the best they can to try and improve and get the benefits out of it at the end of the day. (Builder, Kaiapoi)

No matter what route is taken to reform the LBP scheme, industry feedback suggests a change needs to occur in order to improve Code compliance and accountability regarding leaky constructions.

6.5.2 Improving the skills and education of builders

As earlier detailed, industry feedback specified that a knowledge deficit exists amongst some builders, commonly resulting in the poor execution of installation specifications by some tradespeople. This was indicated to be partly due to insufficient apprenticeship training that does not adequately teach weathertightness prevention skills, an ineffective LBP Scheme and the market for cheap and inexperienced labour created by some clients' preference for low-value contracts.

To combat this, participants firstly suggested that apprenticeship training should be improved upon to include a focus on how to prevent external water ingress.

> As a qualified tradesman of 20 years now, training as a building surveyor, I feel the New Zealand building apprenticeship falls short in the training of its members. I am now only being taught about water and how it enters through a cladding system. If this information was part of the apprenticeship process, it would lift the calibre of tradesmen in this country. (Builder, Cambridge)

It was further proposed that apprenticeship training for builders should be cognisant of other building professions and include modules on other building disciplines. It was widely believed that this would allow for an enhancement of shared understanding of basic building principles within industry and move all building professions in the same direction.

> We all should train together. Currently we all have our own conferences and our own training, why aren't we doing this together? Then [we architects] can then have a conversation [with the builders] so that, when they're reviewing our drawings, we know what they're looking for. But we seem to be training separately through our silos. (Focus group participant, Hamilton)

Some study participants also indicated that the current apprenticeship system allows for builders to teach apprentices their own understanding of water ingress prevention, which can be outdated and non-compliant, allowing substandard builders to teach the next generation their skills and knowledge despite a clear knowledge deficit. This system also relies on the builders taking time to sufficiently upskill their apprentices even though there is no incentive for them to do so.

> I don't think our training's sufficient, but apprenticeships are great. Sometimes you get someone … who's trying to really upskill his guys and then someone else who's got someone pretty much digging trenches and doing formwork for 3 years, just getting by, yet they're coming out [with the same qualifications]. (Focus group participant, Auckland)

> It's the training they're getting on site from who's giving the training. Sometimes you don't know what you don't know … If the person training you is making consistent errors on site, that's the level they're training to. (Focus group participant, Auckland).

It was also identified that some apprentices lack the motivation to complete their written studies and instead rely entirely on the knowledge taught on site. To address this, some employers within our study have considered allocating days where apprentices can focus on their study during periods they would usually be expected to work.

> I thought about giving the apprentice a half day off every week or every fortnight so that they could go in and sit down in the conference room and actually do their study. You shouldn't have to, but otherwise they're not taking themselves off and doing the reading at home. If employers or companies are paid, they shouldn't have to be, but let's say they're paid to give their apprentices half a day off a fortnight to sit in a warm dry environment to do their study – that could be really beneficial. The information is there, it's just getting the people to look at it. (Focus group participant, Hamilton)

For some industry representatives we spoke to, the poor state of apprenticeship training is made apparent when they speak with 'qualified' builders who are perceived to lack a common understanding of weathertight practice and concepts. A lack of basic building knowledge was also indicated to be a consequence of builders being unwilling to update their skills and knowledge and implement new successful methods.

> You talk to a standard builder and you go 'Well we're trying to deal here with negative pressure and things', and they go 'What?' Or you talk about building wrap and why are you using that wrap or why aren't you using a proper product, and they go 'What?' So if you don't have that knowledge, even if the architect who designed it might have specified something, then you still go 'Well I use this product, and why would I tape joints, why would I even think about that?' So it's not on their radar because they don't understand it. (Focus group participant, Auckland)

> I work with builders who are doing stuff the way they were doing things 10 or 15 years ago. They've got worse rather than better as time goes on. Some of them don't understand the first principles of the building sites. It's essential and some of them don't get it and it's not part of the building apprenticeship, it's not even taught. (Focus group participant, Hamilton)

> Many subcontractors I deal with have been relying on what they have always done or what their bosses have taught them. Many of these techniques are incorrect, but they will not accept it when told. (Builder, Cambridge)

In order to ensure that product installation is executed to the desired level, feedback from industry representatives suggests there needs to be reform to the current apprenticeship training scheme. Several research subjects indicated that such reform should be extended to include who is authorised to teach, what is being taught and how it is being taught and to combine the training of professions to allow for greater cohesion and understanding in industry around weathertightness implementation.

6.6 Making information easily accessible

Several research participants recognised that improvements are needed in the delivery of information to industry. Although many identified that information offering solutions to most problems exist, it was acknowledged that it is not tailored to meet the needs of tradespeople who lack the time and motivation to read long, complex resources that are also hard to find. Accordingly, it was expressed that more information should be made freely available, not solely accessible through subscription.

> There needs to be up-to-date details available online for free so everyone can access weathertight details. All standards and BRANZ information should be free. This will remove barriers to ignorance. (Architect, Auckland)

> I can't see any point in not being able to dial up BRANZ and if you want to know how to do a detail, you can actually access something rather than having to get a subscription. Now I know that's ridiculous, but for me, I'd love to see that and to be able to go to the Building Act people and get their opinions too. (Focus group participant, Auckland)

Some study participants specifically indicated a need for the curation of a document that details specifications for weathertightness, thus helping simplify available information.

> There's a brilliant code of practice which was put in our briefing industry, which is a really comprehensive document for roofing and flashing issues and stuff. I just think that we probably need more of those in every aspect of building so that they're readily available for designers and builders to understand. (Focus group participant, Auckland)

> It would be a great idea if there was a brief document covering the critical areas of design because a lot of it is just sort of box ticking specification. If you condense that document down to each area and have six bullet points that are crucial to the execution, [that would be helpful]. (Focus group participant, Auckland)

However, one representative expressed that, regardless of whether information becomes simplified and more accessible, it is likely that the people who should be studying this information will not. They instead suggest that it is up to employers themselves to encourage and require employees to study the information through pointing them towards it.

> I suspect that people who are reading them will look at it. It's the other people who we want to read it. Individually as companies, there's stuff that you can do as well. For the design team, the *Build* magazine, it's got some good articles in it, so we make sure that goes to every team member and they tick off the box saying that they've read it. So we're making sure that the younger people get some information out of it. Companies are not investing a lot of time into making the information available. (Focus group participant, Auckland)

On this topic, some individuals within our study commented on how the implementation of new technology has positively impacted their work in terms of access to information and promoted integration of technology into the workplace to alleviate the issue of accessibility.

> It was great to see E2 and 3604 become 3D available online, and I'm sure that there's a lot more information that could really service the industry about details and solutions … because everyone's got a smartphone now, so all that information's available and I think that it's improving the level of knowledge. (Focus group participant, Auckland)

> It's bringing that knowledge level up so that [we're] not the carpenter of old. The new guys now they're all au fait with phones and all the technology. They're hopping on YouTube and seeing how it's done, which can be scary at times because they might not be doing it right, but it's that knowledge level coming through [that we try to keep up with]. (Focus group participant, Auckland)

> We are currently starting to have a new software, which is helping us to understand the connections between materials and seeing how it works against external and internal moisture and heat transmission. This [new advancement is] going to help the designer and the façade engineer choose a proper detail and junction for different materials. (Focus group participant, Auckland)

These comments suggest that information that is presented simply and is easy to access is likely to have a significant impact in the upskilling of industry members. However, it was further highlighted that, despite how simplified and accessible information is made, it should be the employers' responsibility to make this information available to their workers who may otherwise be too time poor. Digital technology was seen to be key here in terms of increasing accessibility of information in a time-effective way.

7. Conclusion

Despite industry efforts to raise building standards following the leaky housing crisis of the early 2000s, an existing body of research suggests that weathertightness failure remains a pressing issue within the residential construction sector. This study sought to understand industry views regarding why weathertightness failure remains a problem and how the issue can be mitigated. Of specific interest was whether legacy issues from the leaky housing crisis are seen to have an ongoing effect on the residential construction sector or whether a new range of issues have emerged.

7.1 Industry-identified causes of weathertightness failure

64% of survey participants indicated that they have observed weathertightness issues in buildings aged 10 years or less, which indicates that the problem still exists. Survey responses also suggest that weathertightness failure is especially present in complex structures whose design ventures beyond that of traditional homes (i.e. houses with multiple junctions and different cladding types). This indicates a possible correlation between the persistence of weathertightness failure in modern homes and consumer preferences for more diverse building aesthetics.

However, rather than solely blaming trends in contemporary architecture, industry feedback suggests that a multitude of interrelated causes underlie the persistence of weathertightness failure. As raised by survey participants, this encompasses issues such as the influence of underskilled and time-poor contractors within the building workforce, variable practical building knowledge among designers, a licensing scheme that many feel is not working as intended and a regulatory environment that some within the industry perceive as being predicated on compliance rather than building performance. Our research indicates that these issues may be underpinned by a consumer environment in which the desire for housing affordability is prioritised above concerns about construction quality and by the prevalence of risk-avoidant behaviour by some building professionals who seek to limit their exposure to liability.

Collectively, these views suggest that the persistence of weathertightness issues can be attributed to a systems failure within the building industry that exists partly outside of regulatory control.

7.2 Industry-recommended solutions

Industry feedback regarding how to address weathertightness failure was as diverse as the problems that were identified as contributing to the issue. At a high level, many of the solutions posited seek to address facets of how the building and construction industry operates. This reflects a belief that some of the mechanisms that guide how the industry functions paradoxically create conditions that lead to quality issues like weathertightness failure.

Educating clients about procurement

Suggestions to amend procurement practices were evident across all aspects of the study. There was a clear view amongst research participants that a lack of client education about procurement was creating flow-on effects associated with contractor performance and traditional means of ensuring quality control. The prevalence of low-skilled contractors and the lack of on-site checks by architects were two examples

given. An overriding answer to these concerns, according to industry stakeholders spoken to, was for the industry to better inform clients about the consequences of their procurement decisions with the aim to reframe what constitutes value for money.

While some study participants emphasised the importance of procuring qualified and capable contractors, others stressed the importance of ensuring clients understand the benefits of appointing an independent quality assurer to catch issues as soon as possible before they become a larger problem. For some, this involves appointing a clerk of works, while others believed this can be achieved by engaging architects on a full contract.

Introducing proportional liability

Embedded in most construction contracts, joint and several liability invoked the common belief that this rule has given rise to a defensive mentality within the industry, exacerbating construction risk in an attempt to minimise it. As a result of joint and several liability, representatives reported that certain builders were reluctant to register as LBPs in fear of unjustifiably being held responsible for their work. Additionally, it was reported that architects were reluctant to act as quality assurers on site, unless engaged on a full contract, due to lack of liability insurance protection. Again, owing to concerns about liability, it was commented that BCAs were often unwilling to grant consent to Alternative Solutions. To address this, a clear alternative identified was proportional liability, where parties are held liable in proportion to their fault as determined through a judicial process.

Feedback from those we spoke to reflects confidence that implementation of proportional liability will result in architects being more willing to visit construction sites when not engaged on a full contract. It was also felt that proportional liability would result in BCAs being more willing to accept Alternative Solutions that may ensure superior weathertightness protection in some situations than solutions in E2/AS1 currently allow.

Introducing additional solutions to E2/AS1

E2/AS1 was held by most within the study as a sufficient, yet basic, guide to ensuring weathertightness. Some hold the belief that the efficacy of the clause is undermined by some BCAs' reluctance to approve Alternative Solutions, causing architects to rely on a limited range of Acceptable Solutions that are not suitable for all building scenarios. In lieu of BCAs taking a more admissible approach to their assessment of Alternative Solutions, it was held that the industry would benefit if E2/AS1 is updated to include more acceptable design options. It was believed that this would allow the design profession with a greater range of design options applicable to different build scenarios while allowing BCAs to simultaneously continue with their conservative 'check box' approach to consenting.

Improving the skills and education of builders and architects

There was broad acknowledgement that the skills deficit pervading the industry contributes towards the persistence of weathertightness failure. The race to the bottom within the construction market was revealed to adversely affect apprenticeships as some builders are not incentivised to upskill their trainees. Architect training was also identified to be deficient in providing designers with valuable on-site experience, made apparent through the paucity of some graduates' understanding of basic building methodology. Although it is anticipated that graduate architects gain site experience on the job, feedback suggests that this seldom occurs as architectural firms were held to

be less involved in construction observation. Accordingly, several industry representatives felt that reform to how trainees are educated is needed to resolve these issues with greater focus on weathertightness and installation training for building apprentices and trainee architects necessary.

For architects, most feedback indicated that on-site experience and observation would bridge their skills deficit and should be incorporated into the design school curriculum. It was further suggested that emphasising the importance of construction observation as a means of quality control to clients would provide architectural firms more opportunity to expose inexperienced architects to how design is implemented on site. Some research subjects maintained that designers would also benefit from greater consultation with builders during the prebuild phase of construction projects, enabling an early practical test of their design.

In order to ensure that product installation is executed to the desired level, industry feedback also suggests there needs to be reform to the current building apprenticeship scheme, including changes to who is authorised to teach and how building knowledge is taught. It was further proposed that all apprenticeship training should include modules on weathertightness implementation to enable a shared understanding within the industry regarding how external water ingress should be prevented.

Use of 3D design was additionally promoted as being instrumental to facilitating a shared understanding of design between builders and architects. Several research participants maintained that this is essential in order to improve architects' understanding of how their designs will appear to builders and to enhance the detailing of complicated features. Better utilisation of 3D design was specifically indicated as a means to improve weathertightness by ensuring that both parties are on the same page when it comes to the finer, more difficult details of the build.

Reforming the LBP Scheme

While the LBP scheme was felt to contain the bones of a good idea, it was broadly felt to be weak and underutilised, failing to achieve its intended aim of raising industry standards and accountability by setting a low bar for admission. To address this, it was recommended that the scheme should maintain high qualification standards and that registering as an LBP should be mandatory for all who wish to apply a trade. Additionally, it was proposed that amendments to the LBP complaint system should be made to help weed out tradespeople who are not performing to the expected level.

Making information easily accessible to industry professionals

Communication of building information was frequently raised as a key component in the upskilling of industry. However, feedback during the study suggests that some information needs to be purchased and is therefore not immediately accessible for those who need it or is buried within voluminous quantities of installation specifications received for each job. Accordingly, our research participants broadly felt that more work is needed within the industry to tailor information to meet the needs of tradespeople who lack time to read complex resources that are also difficult to obtain.

To address this, there was broad advocacy amongst research participants for more information about standards to be made freely available rather than solely accessible through subscription. Research subjects also largely maintained that greater use of digital technology within the industry is a way to achieve this, with several study participants promoting greater integration of mobile apps in the workplace to make information easier to find.

In summary, the study suggests that a different range of issues from that seen during the leaky housing crisis presently underlies ongoing susceptibility to weathertightness failure in modern homes. This is broadly seen to encompass issues with procurement, skills and education, regulation and quality control. According to those we spoke to, such a multi-faceted issue requires consideration about whether some of the mechanisms that guide how the industry ensures construction quality remain fit for purpose.

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Appendix A: Survey questions

BRANZ

Persistence of weathertightness issues in residential construction

Introduction

Dear research participant,

BRANZ is an independent and impartial research, testing and consulting organisation inspiring the building and construction industry to provide better buildings for New Zealanders.

About the BRANZ weathertightness survey
We are interested in why moisture penetrating the building envelope remains one of the most common and high impact issues facing residential construction in New Zealand.

Questioning why weathertightness issues persist raises several possibilities. First, it is possible that the solutions formed to address weathertightness problems do not account for the different causes of water penetrating the building envelope. A second possibility is that the solutions devised to address weathertightness, although comprehensive, are not being consistently employed. This may owe to contractor negligence, the solutions are not easy to apply, or because the solutions have been ineffectively communicated to the building industry.

Whatever the reason/s, a lack of weathertightness in new residential buildings appears to be a complex problem. BRANZ is interested in investigating this important topic with the aim of providing recommendations for further action.

What you need to do
Taking part in this survey is voluntary and a completed survey implies consent. To complete the survey, simply respond to each question as required. You can pull out of the survey at any time before finishing the questions. However, a completed survey cannot be withdrawn.

Your survey responses will be kept confidential. This means that none of your

answers will be ever be used to identify you.

If you have any questions about the survey, please contact economics@branz.co.nz.

The survey takes about 10 minutes to complete.

What happens to your survey responses?
Once BRANZ receives your completed survey, your answers become part of a large data set where BRANZ can look at trends across all industry representatives who fill in the survey. The data is stored securely and access is restricted to our research team. Once BRANZ has completed the analysis, a research report will be written, and the findings may become part of information resources for the building industry.

Go in the draw to win an iPad Pro!!!
Participants who complete the survey have the option of going into a draw to win an iPad Pro. To be in the draw, you will need to provide your contact details at the end of this survey and have completed the survey by Wednesday 31 July, 2019. The winner will be contacted by BRANZ directly. Your personal details will be kept confidential and stored separately from your survey feedback.

Thank you for taking part.

* 1. What is your primary profession? (please choose one)

- ◯ Architect
- ◯ Engineer
- ◯ Builder
- ◯ Building Surveyor
- ◯ Other (please specify)

* 2. Approximately, how many years' experience have you had in your field? (tick all that apply)

- ○ Less than 12 months
- ○ 1-5 Years
- ○ 6-10 years
- ○ 11-15 years
- ○ 16-20 years
- ○ 21-25 years
- ○ 36-30 years
- ○ 30+ years

* 3. In which parts of New Zealand do you work? (tick all that apply)

- ☐ Northland
- ☐ Auckland
- ☐ Waikato
- ☐ Bay of Plenty
- ☐ Gisborne
- ☐ Hawkes Bay
- ☐ Taranaki
- ☐ Manawatu-Wanganui
- ☐ Wellington
- ☐ Tasman
- ☐ Nelson
- ☐ Marlborough
- ☐ West Coast
- ☐ Canterbury
- ☐ Otago
- ☐ Southland

* 4. Have you witnessed issues with external water ingress in residential buildings less than 10 years old? (please choose one)

- ○ Yes
- ○ No

5. What types of housing did this *primarily* affect? (please choose one)

- ○ Stand alone houses on their own section
- ○ Terrace houses/attached townhouses (These typically have at least one common wall with a neighbouring home or homes, and can be blocks of two or three, or in longer rows)
- ○ Low-rise apartment buildings or blocks of flats (These are up to four storeys high and usually have a common entraceway and shared carpark).
- ○ High-rise apartment buildings (These are typically between 4-6 storeys high and have a common entranceway. These buildings are much taller than low-rise apartments or flats and commonly have elevators).

Other (please specify)

6. What aspects of the buildings were responsible for water ingress? (tick all that apply)

- ☐ Roof cladding
- ☐ External wall cladding
- ☐ Cladding junctions
- ☐ Windows
- ☐ Gutters
- ☐ Spouting
- ☐ Decking
- ☐ Balustrades
- ☐ Don't know

Other (please specify)

7. How severe was the damage that you witnessed caused by the failures to the following building aspects?

	Very severe	Severe	Moderate	Minor	Not applicable
Roof cladding	○	○	○	○	○
External wall cladding	○	○	○	○	○
Cladding junctions	○	○	○	○	○
Windows	○	○	○	○	○
Gutters	○	○	○	○	○
Spouting	○	○	○	○	○
Decking	○	○	○	○	○
Balustrades	○	○	○	○	○

Other (please specify)

8. In your opinion, what are the reasons why weathertightness is an ongoing issue in residential construction? (tick all that apply)

- ☐ E2/AS1 does not adequately address the full range of external water ingress issues
- ☐ Poor quality materials
- ☐ Poor quality design/overly complex design
- ☐ Poor installation owing to a lack of skill and training among contractors
- ☐ Contractors taking a dishonest or lackadaisical approach to their work
- ☐ Contractors rushing to get the job done so they can move onto the next job
- ☐ Poor site management and quality control processes
- ☐ Sub-contractors reluctant to ask for guidance or help if having problems with installation
- ☐ Don't know

Other (please specify)

9. How should weathertightness issues in residential construction be addressed? (tick all that apply)

- [ ] Better communication with the building industry regarding how to achieve E2/AS1
- [ ] Changes to E2/AS1 to better address the range of weathertightness problems
- [ ] Better quality design
- [ ] Training modules for contractors on how to address and prevent common weathertightness issues
- [ ] Better site management and quality control processes
- [ ] Cultural change within the construction industry so that sub-trades feel confident to ask for help when uncertain
- [ ] Don't know

Other (please specify)

10. Do you have any other comments about weathertightness issues in residential construction?

11. Are you interested in participating in a follow-up research to discuss weathertightness issues in residential construction in greater detail? (This will be either a one-on-one interview with BRANZ researchers or a BRANZ-led focus group along with other industry representatives.)

- ○ Yes
- ○ No

12. Would you like to go into the draw to win an iPad pro?

- ○ Yes
- ○ No

13. Please enter your contact details if you wish to go into the draw to win an iPad Pro and/or wish to be contacted to participate in future BRANZ research on the topic of weathertightness.

Name	
Company	
Address	
Address 2	
City/Town	
ZIP/Postal Code	
Country	
Email Address	
Phone Number	

Appendix B: Survey responses and analysis

In total, 215 building professionals participated in the survey, representing 10 different professional categories (Figure 7 and Table 3).

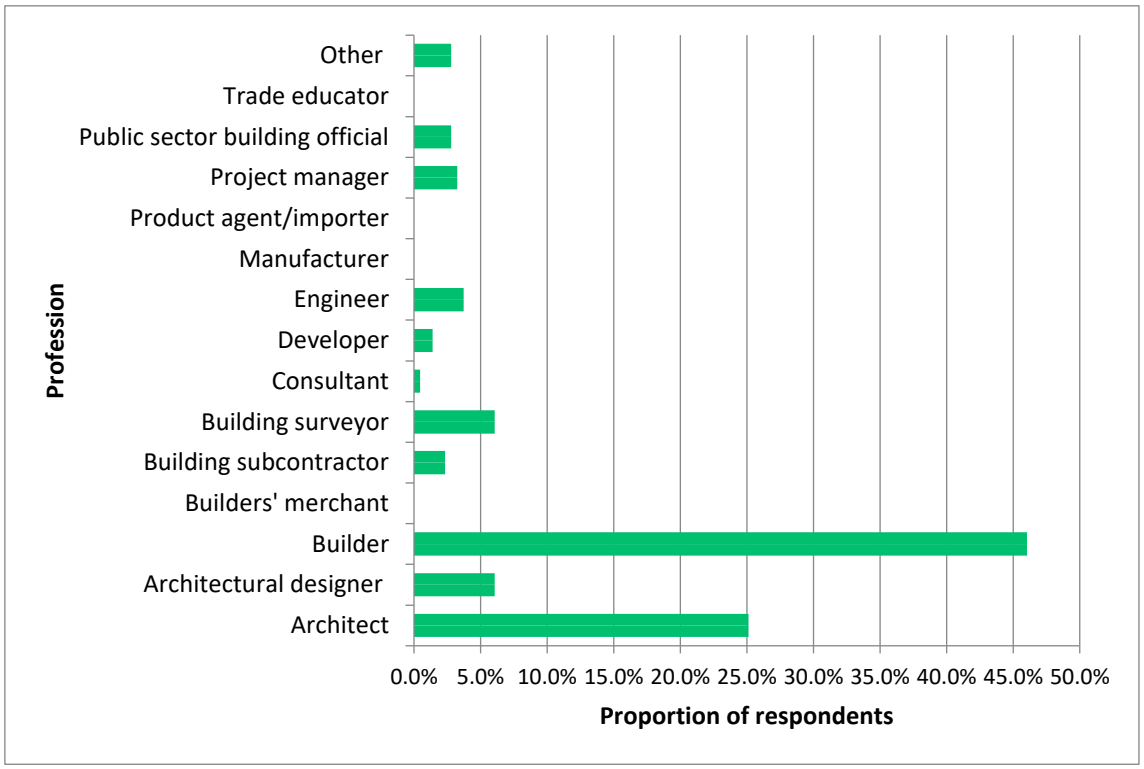

Figure 7. Profession of survey participants.

Table 3. Profession of survey participants.

Profession	Responses	Individual mentions
Architect	25.1%	54
Architectural designer including draughtsperson and product specifier	6.1%	13
Builder	46.0%	99
Builders' merchant	0.00%	0
Building subcontractor	2.3%	5
Building surveyor	6.1%	13
Consultant	0.5%	1
Developer	1.4%	3
Engineer	3.7%	8
Manufacturer	0.00%	0
Product agent/importer	0.00%	0
Project manager	3.3%	7
Public sector building official	2.8%	6
Trade educator	0.00%	0
Other (please specify)	2.8%	6

Participants were highly experienced in their respective fields, with 73% of survey participants working in their area for 16+ years and over 30% having 30+ years' experience within their chosen profession (Figure 8 and Table 4). Accordingly, most survey participants were working within their field during the height of the leaky building crisis and had experienced the changes associated with amendments to the Building Act in 2004.

Figure 8. Number of years working in profession.

Table 4. Number of years working in profession.

Years	Responses	Individual mentions
Less than 12 months	0.9%	2
1–5 years	4.2%	9
6–10 years	4.7%	10
11–15 years	17.2%	37
16–20 years	13.5%	29
21–25 years	17.7%	38
26–30 years	10.2%	22
30+ years	31.6%	68

Although the study targeted people with different industry backgrounds, certain industry types were more represented than others. Of the 215 participants, 46% worked in Auckland (Figure 9 and Table 5) and 46% were builders (Figure 7). This is likely because approximately half of all survey respondents (108) were recruited with the help of Registered Master Builders, and many were Auckland-based.

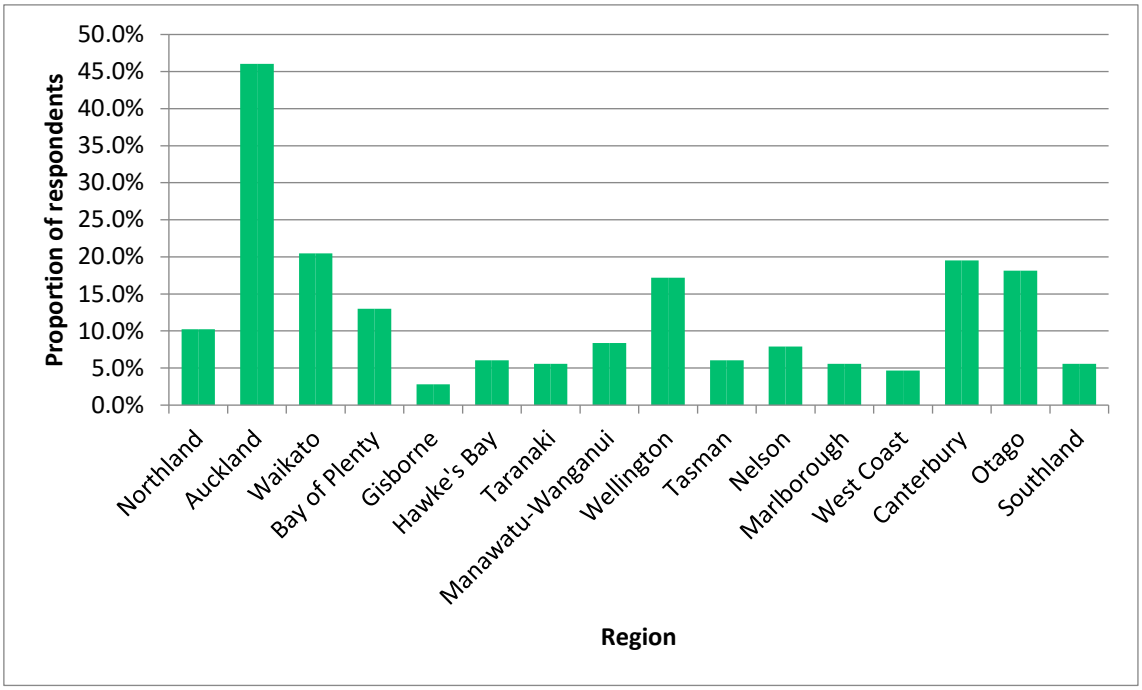

Figure 9. Areas of New Zealand where survey participants work.

Table 5. Areas of New Zealand where survey participants work.

Profession	Responses	Individual mentions
Northland	10.2%	22
Auckland	46.1%	99
Waikato	20.5%	44
Bay of Plenty	13.0%	28
Gisborne	2.8%	6
Hawke's Bay	6.1%	13
Taranaki	5.6%	12
Manawatu-Wanganui	8.4%	18
Wellington	17.21%	37
Tasman	6.1%	13
Nelson	7.9%	17
Marlborough	5.6%	12
West Coast	4.7%	10
Canterbury	19.5%	42
Otago	18.1%	39
Southland	5.6%	12

Appendix C: Focus groups and interviews

Each of the 67 people who indicated via the online survey that they were interested in participating in follow-up research were sent an email invitation to participate in either a personal phone interview or focus group discussion. Determining who to invite to a focus group or to participate in a phone interview was decided by the number of people who indicated interest in any given population centre. As shown in Table 6, interest in participating in further research was concentrated in Auckland and Hamilton. It was therefore determined that recruiting enough numbers to hold focus groups in these areas was more realistic compared to the other population centres.[9] Focus groups were utilised as an efficient means to talk to a range of building professionals about the topic simultaneously. All other building professionals outside of Auckland and Hamilton were sent invitations to participate in individual telephone interviews.

Table 6. Number of people who registered interest in participating in further research by area.

Area	Number of people who registered interest in participating in further research
Whitianga	1
Whakatane	1
Auckland	25
Hamilton/Cambridge/Te Awamutu	11
Tauranga/Mt Maunganui	2
Rotorua	3
Napier/Hastings	2
New Plymouth	2
Palmerston North	3
Porirua	2
Nelson	1
Rangiora	1
Kaiapoi	1
Christchurch	4
Temuka	1
Timaru	1
Queenstown/Arrowtown	4
Dunedin	1
Invercargill	1

The 25 building professionals from Auckland were sent an email invitation on 4 September 2019 to participate in one of three separate 2-hour focus group discussions at the Crown Plaza Hotel, Auckland Central, across the dates of 23–25 September 2019. The invitees were given the option of choosing which session time most suited them, with a maximum of 10 spots for each session.

11 people from Hamilton were sent an email invitation on 4 September 2019 to participate in a 2-hour focus group discussion at Hamilton's FMG Stadium on 2 October 2019.

[9] Based on the principle that focus groups need a minimum of six people to be effective.

Invitations were followed on 5 September by phone calls to each invitee across both cities. As shown in Table 7, this resulted in the recruitment of 19 focus group participants in Auckland and six in Hamilton.

Table 7. Number of focus group participants per session.

City	Session	Number of focus group participants
Auckland	23 September 2019	9
	24 September 2019	8
	25 September 2019	2
Hamilton	2 October 2019	6

The four focus groups held across Auckland and Hamilton represented the views of 25 people across eight different professional backgrounds (Table 8). This enabled BRANZ to capture a range of perspectives when discussing themes that emerged from the online survey.

Table 8. Focus group participants.

Profession	Proportion	Number
Architect (including design and build architects)	24%	6
Architectural designer	8%	2
Builder	32%	8
Building surveyor	12%	3
Developer	4%	1
Façade engineer	12%	3
Project manager	4%	1
Local government building inspector	4%	1

Invitations to participate in a phone interview were emailed on 9 September 2019 to the 32 remaining individuals outside of Auckland and Hamilton who had registered their interest through the online survey. Each person was asked to reply to the email to confirm whether they consented to being called to discuss the issue in greater depth and were asked to indicate times of the day that it was best to contact them. This resulted in 15 positive responses, from which 13 phone interviews and one face-to-face interview were able to be arranged.[10] Phone interviews with these individuals commenced on 17 September 2019 and continued until 9 October 2019.

A balance of industry perspectives was also achieved during the interview process, with equal numbers of builders and architects and the addition of a director of a South Island-based multi-disciplinary engineering consultancy (Table 9).

Table 9. Interview participants.

Profession	Proportion	Number
Architect	46%	6
Builder	46%	6
Engineering consultant	8%	1

[10] Interviews with three interested people were unable to be arranged owing to their busy schedules.