Regulatory barriers associated with prefabricated and modular construction

Interim Report

May 2022

Preface and Acknowledgement

Swinburne University of Technology (SUT) is undertaking research and development work on regulatory barriers for off-site construction focusing on prefabricated and modular buildings. The project is commissioned by the Housing Industry Association (HIA) on behalf of the Advanced Manufacturing Growth Centre's Prefab Innovation Hub. The HIA is the project sponsor. This work forms part of a series of projects being supported by the Advanced Manufacturing Growth Centre Prefab Innovation Hub.

This project aims to develop a report that identifies and analyses the regulatory barriers for off-site construction. The project is conducted in two phases.

The first phase involved developing a Briefing Paper to provide background information and key issues that had been identified by the project team. This was shared with stakeholders which were consulted to provide their opinions and experience.

The second phase of the project will be a Final Report which will incorporate the findings from the consultation to provide recommendations for future work and implementation options to address the identified regulatory barriers.

This Interim Report provides a draft of the key findings to be included in the Final Report.

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1 Introduction

1.1 Background

Australia's building codes and standards, along with the regulatory systems that apply to zoning land and approving the construction of buildings, are written based on traditionally (conventionally) constructed buildings, products, practices and systems.

As a result, they introduce challenges with regulatory acceptance and approvals with respect to off-site construction methods, including prefabricated (prefab) and modular construction.

This can be time consuming and costly and results in inconsistent outcomes for industry and consumers, with the potential for non-approval. This can also result in manufacturers and suppliers being hesitant to bring new products and systems to market given the inconsistency and uncertainty.

The regulatory system for building practitioners is already very complex to navigate for conventional construction and it is even more of a complex web for prefab and modular construction.

In addition, the regulatory requirements for small scale residential construction and financing by home buyers also fail to recognise alternative construction methods (such as prefab and modular construction) and contract arrangements making finance for new homes difficult.

Given the likelihood of a steady increase in fast-tracked building construction, a vast number of construction projects including housing, will move to off-site and modular or systems-based construction methods over the next 5, 10 and 20 years.

It is critical that there is a clear understanding of the regulatory barriers that exist today and that potential solutions are identified now.

These regulatory systems will need to be updated and revised to remove the unnecessary barriers to enable greater uptake and recognition of the suitability and effectiveness of prefabricated and modular construction and to facilitate an appropriate and streamlined process for the necessary approvals.

1.2 Project objective and scope

The objective of this project is to identify regulatory issues that need to be addressed and potential opportunities to facilitate the use of prefab and modular construction in Australia.

The project will examine regulatory barriers for residential buildings (single dwellings) and low- to mid-rise buildings (multiple dwellings).

The aspects of the regulatory requirements which will be explored includes:

- planning and building approvals,
- building codes and standards,
- testing and certification,
- practitioner licencing, stage inspections and contractual requirements,
- transport, and
- other local government regulations (e.g. manufactured homes).

Temporary structures or other temporary or short-term accommodation buildings are not within the scope of this project.

1.3 Definitions

Many terms are used and have been used when referring to modular and prefab construction and similar off-site or pre-manufactured homes and building elements.

Off-site construction, also referred to as off-site manufacturing (OSM) or design for manufacture and assembly (DfMA), refer to a method of construction of buildings with components that have been fabricated 'off-site' or away from the building location.

These buildings typically have prefabricated or modular components and are commonly referred to as **prefab or modular buildings**.

For the purpose of this paper the terms **modular and prefab construction** will be predominantly used.

It should be noted within this context the terms **modular and prefab construction** and within this project and identifying regulatory barriers, construction types such as 'tiny homes', 3D printed homes, bathroom and kitchen pods and multiple purpose/function building elements are all within the scope of discussion for this project.

However, it is likely that different and more nuanced solutions would be needed to the different types of modular and prefabricated construction.

From regulatory perspective, a definition or classification enables appropriate and effective measures necessary for each class of products to achieve compliance and quality assurance.

Classification can be used to determine the level of pre-fabrication; an example is shown in Figure 1.

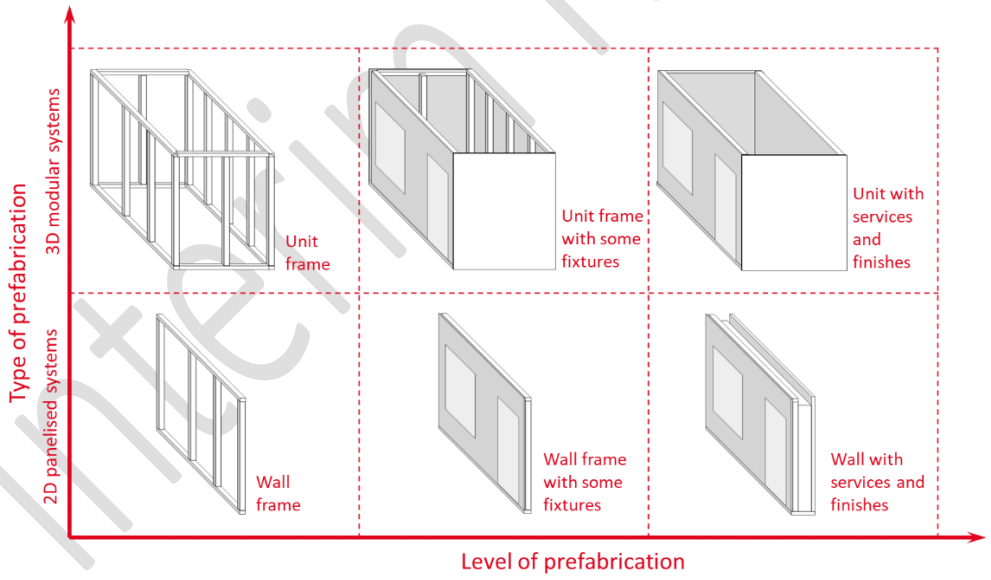

Figure 1: Type and level of prefabrication

There are three basic types of prefabricated systems.

- **Simple components (1D prefab):** most components in construction involve some form of prefabrication for ease of on-site erection, for example steel beams and columns manufactured to be easily bolted on site. The compliance and quality assurance processes for these products are well established.

- Panelised systems (2D prefab): assemblies of components designed for ease of transport and erection. Panelised systems vary from basic system design to serve a specific purpose such as structural panels for roofs, walls and floors, internal/external cladding system to complete panel systems to serve multi-purpose.
  How to assess the level of compliance and quality of these off-site products could become problematical for complete panelised systems.
- Modular systems (3D prefab): this term is often reserved for pre-assembled three-dimensional products varying from single utility units such as bathroom pods or prefab classrooms to a full residential unit (an apartment or a house). The technical evaluation of these units is problematic since the regulatory system was not designed for this type of product.

The classification in terms of the source of fabrication may also be important. Products that are manufactured overseas face another layer of regulatory barriers associated with imports on top of the usual building control measures which is already difficult to implement for the lack of access.

Therefore, the need for clear set of agreed definitions is critical in developing specific regulatory triggers or tailored building or planning codes and standards requirements.

2 Overview of Australian practice

Residential construction and all other forms of building construction is subject to a raft of regulations and controls based on the planning and building administrative frameworks in place in each state and territory.

With respect to housing, the planning systems in each state and territory appear to pigeon hole a modular home as a manufactured home and not consider their use as a home on a residential block of land.

Planning agencies will at times say the planning system does not have rules and at other times say the rules apply in the same way as they would to a house built on-site.

Some states and territories perpetuate a separate set of building rules for manufactured homes based on the historical caravan park regimes in place decades ago.

Some suggest the National Construction Code (NCC) does not or should not apply, regardless of where the building is located.

Critically prefab and modular housing design is no different to conventionally built houses.

However, the design and construction stages are managed very differently which can lead to different interactions with the planning and building administration framework including the approvals required.

Prefab and modular housing are generally constructed in two stages, described in Figure 2. These stages must be correctly identified for the regulatory approval and inspection requirements to meet the satisfaction of the regulatory body (council or building surveyor/certifier).

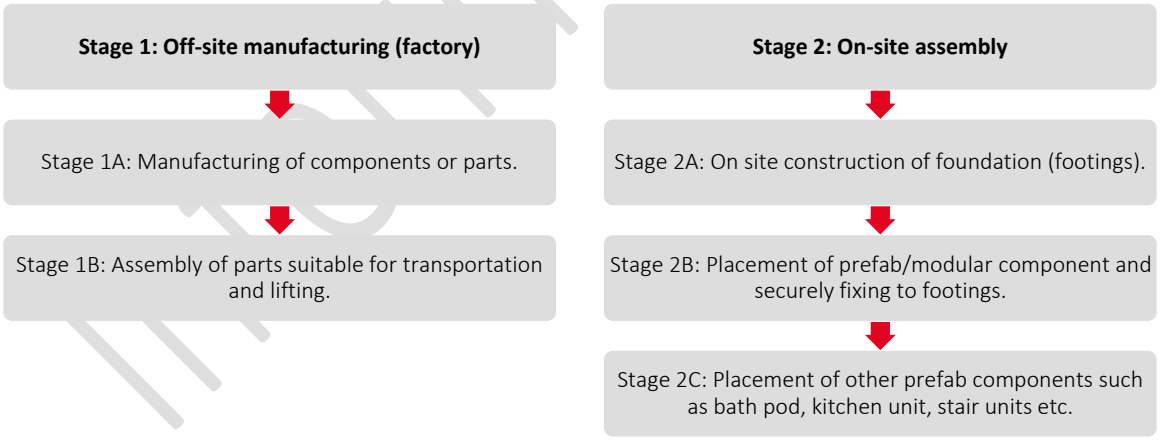

Figure 2: Two key stages of construction for prefab and modular housing

Prefabricated and modular construction is also being used regularly for building components in residential, multi-residential and commercial projects. The regulatory barriers for these individual components are experienced differently to a full modular structure brought to site.

It is considered that there is a need to consider both types of prefabricated and modular construction in their own right in setting new or tailoring existing regulations as they present slightly different challenges. Furthermore, the solution for one may not adequately address the other and vice versa.

2.1 Australian research

The construction of prefabricated and modular housing in Australia has been increasing over the last decade. Multiple initiatives have taken place to assist with the development of off-site construction in Australia, including:

- prefabAUS: the peak body for Australia's prefabricated building industry, formed in 2012(prefabAUS, 2021).
- The Australian Research Council (ARC) Training Centre for Advanced Manufacturing of Prefabricated Housing (CAMP.H): administered by the University of Melbourne(The University of Melbourne).
- Sustainable Built Environment National Research Centre (SBEnrc): formed in 2010 acts as a research broker between industry, government and research organisations to provide support to the built environment industry(Sustainable Built Environment National Research Centre (SBEnrc)).
- Advanced Manufacturing Growth Centre (AMGC) Pre-Fab Innovation Hub: The Pre-fab Innovation Hub was announced by Karen Andrews, then Minister for Industry, Science and Technology on 16 June 2019 to support Australia's manufacturing and building and construction industry.
  The AMGC first undertook a feasibility study for a manufactured building hub for the prefabricated building industry. The Hub allows the development and implementation of the following outcomes:
    - support links between the construction and manufacturing sectors to enable businesses to benefit from advanced manufacturing processes
    - support new technologies and innovations enabling the transformation of the industry to provide smarter, more affordable and more sustainable construction solutions for Australians
    - grow the manufactured buildings eco-system to improve business capability to incorporate advanced technologies and processes within industry

  HIA's project forms part of a series of projects being supported by the Prefab Innovation Hub.
  The Pre-fab Hub is supported by a Steering Committee comprised of broad range of experts with representatives from industry, research organisations, including HIA and Pre-fab Australia.
- Modular Construction Codes Board (MCCB): published the first handbook for the design of modular structures in Australia in 2017(Modular Construction Codes Board (MCCB), 2017).

Much of the research from the above initiatives and other researchers have focused on general barriers or constraints for the uptake of off-site manufacturing, including:

- Financial challenges
- Capacity limitations
- Transportation and installation challenges
- Greater importance for project planning and coordination activities
- Difficult in applying planning and building codes (developed for traditional methods)
- Insufficient government regulations and incentives
- Negative community mindset
- Industrial issues and business politics

While it has been identified that regulatory systems for buildings in Australia require attention to address prefab and modular construction, a consolidated and specific research approach has not occurred to date.

2.2 Construction process and approval requirements

The general critical stages for the construction of a building with modular and prefab components and the corresponding approval requirement and the responsible party is shown in

Table 1. And an overview is shown in Error! Reference source not found..

The different stages of construction may include regulatory and non-regulatory requirements. While this study aims to focus on regulatory barriers, some issues which are not considered directly as regulatory will also be discussed.

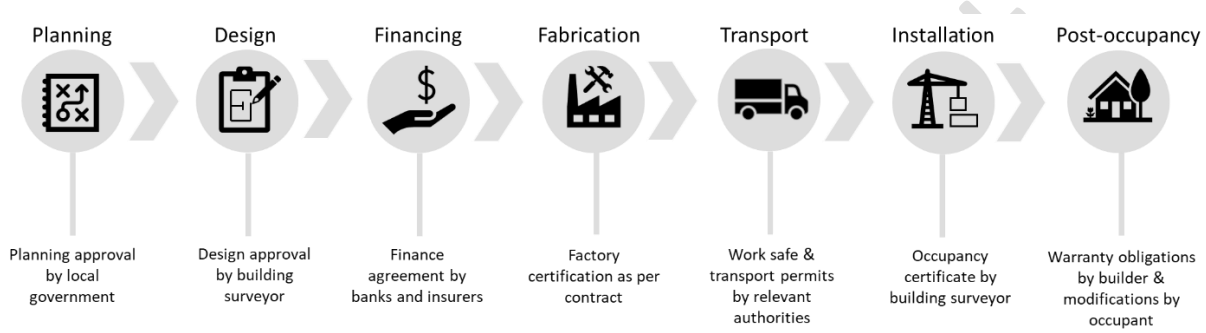

Figure 3: Overview of the construction process for prefab and modular products

Table 1: Approval requirements including regulatory requirements for the various stages of construction

Construction stage	Approval requirements	Responsible party
Planning and conceptual design	Development /planning approval – approval to develop land in a particular way.	Submitted by builder/designer on behalf of the owner and typically granted by local council.
	Funding approval/bank guarantee.	Submitted by owner/developer.
Detailed design	Building approval – approval that proposed building complies with relevant building regulations (compliance with the NCC performance requirements).	Completed by builder/designer and approved by building surveyor with consent required authorities, e.g., local council.
Manufacture of off-site components	Manufacturer quality assurance procedures.	Manufacturer and supplier.
	Inspection of components once completed and assembled.	Authorised inspector/supervisor reporting to the building surveyor.
Transportation from factory to site	Approval for transportation, including heavy vehicle requirements.	Temporary works engineer employed by the builder/work safe.
Storage on site	Approval for storage of components on site.	Project engineer representing the builder.
Installation of prefab/modular components	Inspection of modules prior to installation.	Project engineer representing the builder.
	Temporary works.	Temporary works engineer representing the builder.
	Work safe requirements prior to installation.	Temporary works engineer representing the builder.
	Inspection of modules during installation.	Project engineer representing the builder.
Installation of mechanical, electrical and plumbing (MEP)	Certification of products.	Licensed mechanical service worker, electrician and plumber.
Installation of finishes (partition walls, doors, flooring etc.)	Certification of products or work as necessary.	Licensed trade person as necessary.
Completion of building works	Occupancy permit or a certificate of final inspection.	Approved by building surveyor (typically a requirement of the building approval).
Post-occupancy	Building warranty	Warranty obligations by the builder, home owner maintenance

2.3 Building codes and standards

The planning and building administrative framework in each state and territory calls up the NCC to set the technical standards for the design and construction of buildings in Australia.

The NCC is a performance-based building and plumbing code, meaning the mandatory requirements of the NCC are the Performance Requirements and compliance can be achieved in following the prescriptive Deemed-to-Satisfy Provisions (DTS) or in developing a Performance Solution that can allow for innovative solutions.

Under the DTS pathway the NCC calls up a range of relevant standards (Australian Standards and others) which set benchmarks for the material, design and construction requirements, for example:

- AS 1684 for timber residential construction and AS 1720 for timber structures,
- AS 2870 for residential slabs and footings and AS 3600 for concrete structures design,
- AS 3740 waterproofing of wet areas,
- AS 4100 for steel design and AS 4600 for cold-form steel design,
- AS 4773 for masonry for small buildings and AS 3700 for masonry design.

Whilst a builder and designer could adapt or apply these Australian Standards, or the principles contained within them to a particular construction type, they have generally not taken into account or specifically been drafted with off- site and modular and prefab construction in mind.

Similarly, the DTS Provisions of the NCC are written with conventional construction in mind and for products to be generally serving a specific purpose to satisfy the NCC rather than a full wall or roof system for example encompassing numerous parts required for NCC compliance.

This leaves builders, designers and manufacturers either trying to make the product fit into the NCC DTS Provisions, developing a Performance Solution specific for the building or some form of a hybrid solution. This results in inconsistent approaches, uncertainty in approvals and hesitancy to stick with the tried and tested as opposed to bringing new and innovative solutions to market.

The issues are particularly more challenging for high-level prefab components (complete panel or modular unit) to be explored. A high-level prefab product will require multiple aspects of performance to be evaluated, for example a complete wall panel will have to satisfy structural requirements, fire requirements, acoustic requirements, water proofing requirements (if external).

Furthermore, imported products may require specific installation procedures (that may be implicit in the traditional practice of the country of origin), without which it will not perform as expected (example Japanese window units perform badly when installed in Australia/New Zealand).

2.4 Building product conformity

In conjunction with the detailed design and construction requirements of the NCC and Australian Standards, a core component is requirements for building product testing, certification and approval (building product conformity).

The NCC contains building product conformity requirements under the 'evidence of suitability provisions' which lists product evidentiary requirements and ways for which a material, product, design or form a construction to demonstrate compliance with the NCC(Australian Building Codes Board (ABCB), 2019a, 2019b).

Many of the Australian standards referenced in the NCC contain testing requirements for products to show compliance with that standard.

Under these provisions the NCC provides a number of ways to demonstrate compliance these are:

- A CodeMark certificate of conformance,
- A certificate of accreditation under a state government certification scheme (where one exists),
- A test report by a National Association of Testing Authorities (NATA) lab,
- A certificate issued by a certification body accredited by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) – this includes industry schemes such as ACRS and EWPAA schemes,
- A certificate or report by a professional engineer or other appropriately qualified body,
- Another form of documentary evidence such a Product Technical Statement or Technical Appraisal.

Whilst this framework exists and could apply to singular modular elements or full systems there are shortcomings to this. For example, NATA and JAS-ANZ will generally accredit a testing lab or certification body to issue certificates or reports against a scope of accreditation to specific Australian Standards.

Furthermore, the way the NCC and Australian Standards have been designed generally requiring testing or approval against specific tests for say fire or acoustics not both in the same test. Hence that product requires multiple tests to show the full suite of NCC compliance rather than holistic performance of the completed element test.

Similarly, given the NCC and Standards are written generically, many of the modular and prefab construction products and systems differ greatly from manufacturer to manufacturer, so a single standard or specification may need to be developed specifically to that product which is not an approach used elsewhere.

2.5 Supply chain responsibilities

With prefab/modular construction the components (parts) are either made in a factory by the builder or supplied by a subcontractor and assembled either by the builder or subcontractor in the factory. Hence the chain of custody varies with project to project. In general, the following applies:

- Builder (main contractor): is responsible for planning and implementing all the activities involved in the construction of the building, including undertaking of the on-site construction and installation work. The builder is responsible for everything.
- Architect and design engineer: is responsible for the design of the building and to meet the requirements set by the NCC and other applicable standards/specifications.
- Prefab/Modular manufacturer/supplier: is responsible for the prefab or modular component (product).
- Subcontractor: is responsible for on-site construction and installation work which is outside of the expertise of the builder (e.g., mechanical service workers, electricians and plumbers).
- Building surveyor/certifier: is responsible for providing independent oversight of the building construction process and ensure upon completion the building is safe and meets all necessary requirements. They assess and approve applications for building permits, undertake inspections of building/building work and approve building occupation.
- Government authorities: is responsible for granting planning and building approvals (e.g., local council and state regulators).

Furthermore, the temporary works engineer must be deployed by the appropriate manufacturer/assembler/ subcontractor/builder for the following activities:

- Fabrication and assembly: the builder/subcontractor must ensure all workmanship is certified by engineering representative.
- Storage: the builder/subcontractor must ensure that the storage of components is designed/certified by the engineering representative.
- Transportation: components must be designed to withstand additional loads from the required mode of transportation (e.g., road, rail, sea or air). This must be designed and certified by engineering representative.
- Installation: lifting certificate must be issued by the engineering representative for installation of components in the factor or on-site.

Chain of custody plays an important role especially if issues arise such as damage to components. The type of problems vary with the degree of prefabrication and off-site construction. It is critical that fully assembled modules are checked on-site by certified engineers/architects prior to installation.

If a component is damaged, the responsible party needs to be identified and the components must be returned to the factory for assessment and repair.

If damage occurred during transportation; the transportation company is responsible, however, the engineers must demonstrate that all precautions have been taken to minimise damages due to additional imposed actions during transportation. It's also necessary to ensure that the component was not damaged prior to transportation, if so, the manufacturer/supplier would be responsible.

2.6 Financial and contractual issues

Building a home is subject to a raft of consumer laws that impact the contractual arrangement between a builder and a home buyer. These laws broadly assume a home is built on-site and that stages of progress are reached to allow partial payment to a builder.

A prefab or modular home built wholly off-site is treated as a manufactured product with different payment regimes in place, either deposit at the start and full payment at end or full payment before work starts.

Neither of these arrangements suit home lending arrangements in the traditional sense. In most jurisdictions, these same consumer laws will only apply once the work is captured by domestic or residential building law, i.e., most off-site work is not captured and therefore not regulated by these arrangements.

This offers both challenges and flexibility depending on the circumstances of the parties involved.

For example, limits on deposits that apply when carrying out home building work on site will not apply to the manufacture of pre-fabricated building components allowing the manufacturer more flexibility to charge for the works being carried out.

3 Overview of overseas practice

Prefabricated housing has gained great momentum in some countries such as Japan and Scandinavian and Northern European countries, and a fluctuating popularity in other countries such as the United States and United Kingdom since post war period.

For most countries the modular industry is still largely regulated by the same codes as conventional construction. However, significant work has been conducted to improve the compliance and quality assurance (QA) of prefabricated and modular products and construction process. Some of these measures includes:

- Third-party certification of factories, products and processes which often involves surveillance and inspections,
- Manufacture self-certification and quality control procedures,
- Product identification and traceability systems,
- Development of standards and guidelines for prefabricated buildings, and
- Schemes to provide assurance to lenders.

The following sections provides an overview of off-site construction in countries which have a varying level of off-site manufactured buildings, namely: Japan, Sweden, Canada, Singapore, United Kingdom, and New Zealand.

3.1 Japan

Japan is considered as one of the world-leaders in prefabricated and modular housing industry. Approximately 15% of new construction are modular and it has the largest volumetric modular company in the world, Sekisui Heim, which has produce more than 10,000 house units (Modular Building Institute, 2019).

The development of manufactured homes started in the 1960s and 1970s due to high demand for housing for which conventional construction was unable to meet (Friedman, 2021). Initially, prefabrication and modular construction was developed to speed up construction and increase affordability of houses.

However, since the 1970s Japan changed its focus to superior quality and now volumetric houses are approximately 8% more expensive than conventionally built houses (Modular Building Institute, 2019).

Quality assurance and guarantee is typically provided by large companies with strong reputations. Japanese companies take great care to develop houses with high level of durability, advanced features, warranties and post-occupation care (Manley & Widén, 2019).

It is common for manufacturers to demonstrate the reliability of their products through earthquake, fire and water resistance tests at publicly-available laboratories (Manley & Widén, 2019).

In addition, advanced features in relation to air quality, sound insulation, thermal insulation and envelope seal are provided as a standard. Manufacturers typically fix defects without additional costs to consumers and follow the “Home Guarantee System” and “After Sales and Maintenance Service System” strategies introduced in the 1960s, to provide services such as upgrades, renovations, and re-customization (Linner & Bock, 2012).

In addition to manufacture quality control systems, third-party certification is also necessary. The Minister of Land, Infrastructure, Transport and Tourism (MLITT) established the housing performance labelling system and certifies private companies to conduct assessments to issue performance evaluation of houses (Chang-Richards et al., 2019). Prefabricated buildings come with a standard 20-year warranty which includes after sales service provisions (SBEnrc, 2017).

Many Japanese companies have sought to replicate their construction methods in Australia but ultimately have elected to follow ‘ the Australian way’ due to the inability to navigate our complex regulatory environment.

3.2 Sweden

Sweden, similar to Japan, is also considered to be a leader in prefabricated and modular buildings due to its high rate of adoption compared with other countries. However, success is related to a highly-skilled workforce that has valued research, training and understanding of new systems instead of technological advances and automation (Manley & Widén, 2019).

Leading firms initially started with providing single-family homes and now predominantly focus on affordable multi-unit housing (Modular Building Institute, 2019).

Sweden's volumetric modular construction is governed by conventional building codes (Modular Building Institute, 2019). It has a national type approval system for assessment and verification of construction products with requirements in the Swedish building regulations.

Type approvals are provided for products which are not covered by harmonised standards and European Technical Assessments (ETAs) (Boverket, 2021). As part of the validity of the approval, manufacturing process is inspected regularly by a third-party (Research Instute of Sweden (RISE)).

The study conducted by Chang-Richards et al. (2019) demonstrated that self-certification is the primary mechanism used for quality assurance.

This is then followed by third-party inspection and certification of factory production process and factory facilities/capacity. The high-quality focus seems to be a norm due to the high uptake of prefabrication in the housing sector and hence requires less regulatory interventions.

3.3 Canada

Modular construction has gained popularity in Canada since end of World War II with the booming of Canada's population and economy. It's approximated that in the last decade, factory built residential houses compose of 8-16% of the total single family housing market (Norman & Bray, 2020).

The Canadian Standards Association (CSA) has developed three standards which are directly related to prefabricated and modular buildings:

- **CSA A277-16 (R2021): Procedure for Certification of Prefabricated Buildings, Modules, and panels.** This standard provides the procedure for certifying buildings, and partially or fully enclosed modules and panels for buildings of any occupancy. It provides requirements for certification of the factory quality program and the prefabricated product, auditing of the factory quality program; and in-factory inspection of the prefabricated product.
- **CSA Z240 MH Series-16 (R2021): Manufactured Homes.** This standard provides general requirements for manufactured homes, including technical requirements, and requirements on quality control, markings, and provision of printed instructions.
- **CSA Z240.10.1:19: Site preparation, foundation, and installation of buildings**. This standard provides requirements related to building installation, including: site preparation, permanent foundations, anchorages to resist overturning and pier toppling due to wind, connection of modules, and skirting.

In addition, prefab and modular buildings must comply with province and territory building code requirements and additional certifications are used to quantify other aspects of the modular buildings including energy efficiency and sustainability (BC Housing, 2014).

The manufacturer is responsible for implementing quality control procedures to ensure compliance with necessary performance requirements. Furthermore, factory surveillance inspections are conducted by a third-party to assess manufacturer quality control procedures and to ensure the building complies with all necessary performance requirements (Chang-Richards et al., 2019). A summary of the quality assurance and compliance procedure in accordance with CSA A277 is shown in **Figure 4**.

Figure 4: Approval process in accordance with CSA A277, adapted from Chown (2015).

3.4 Singapore

The government in Singapore is encouraging construction companies to use construction methods which require reduced labour such as modular construction through implementing various schemes and incentives (Shang et al., 2020). The Singaporean Building and Construction Authority (BCA) has developed an acceptance framework for modular construction, referred to as prefabricated prefinished volumetric construction (PPVC), on mandated development sites (BCA, 2022). It consists of two parts:

(i) Acceptance by the Building Innovation Panel (BIP), and
(ii) Accreditation by PPVC Manufacturer Accreditation Scheme (MAS).

An overview of the process involved for acceptance by BIP is shown in **Figure 5**. The suppliers and manufacturers need to ensure that their PPVC systems meet the building code performance requirements and submit an application to BIP. BIP seeks suitable regulatory authorities to provide feedback about the application. If accepted, In Principle Acceptance letters are issued to the supplier/manufacturer and are listed on the BCA's website. Additional accreditations are also required via the Precaster's Accreditation Scheme for PPV shell production and PPVC Manufacturer Accreditation Scheme for fitting out works. The PPCV MAS is managed by the Singapore Concrete Institute and the Structural Steel Society of Singapore. The scheme ensures quality assurance and control in the production of PPVC and sets the process for manufactures to produce high quality PPVC systems.

Figure 5: Building Innovation Panel PPVC acceptance process (adapted from BCA (2022))

3.5 United Kingdom

Modular construction became popular in the UK during post-war period in the 60s due to high demand for housing, however its popularity reduced with decrease in demand and collapse of the Ronan Point apartment tower in London in 1968 raising concerns about the safety of prefabricated housing (Bertram et al., 2019). Currently, the UK is again seeing more prefab and modular projects. In 2013 the Build Offsite Property Assurance Scheme (BOBAS) was launched to encourage off-site construction. BOPAS is a risk-based evaluation which provides assurance to funders, lenders and purchasers that buildings constructed using non-traditional methods and materials will last for at least 60 years (BOPAS, 2021)

The relationship between UK regulations and standards is shown in Figure 6. The British Board of Agrément (BBA) is the UK body which issues certificates for construction products against various schemes (e.g., BBA Agrément, European Technical Assessment, CE marking) to demonstrate fitness of purpose of the product and compliance with various building regulations. During the validity of the certifications manufacturers may be audited to ensure adequate quality management systems and repeated testing may be required (Chang-Richards et al., 2019).

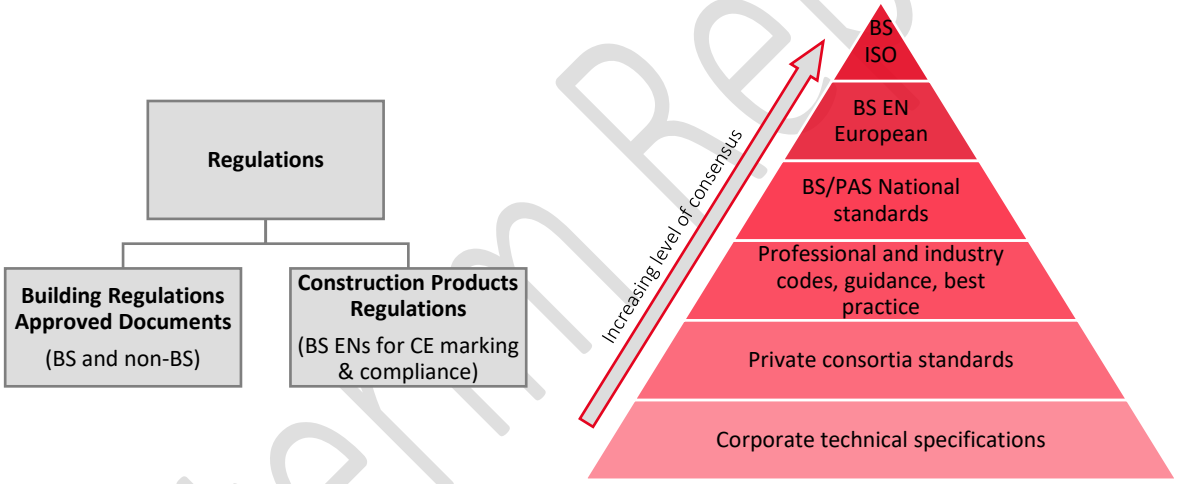

Figure 6: Relationship between standards and regulations and level of consensus for different standards and specifications, adapted from BSI (n.d.)

In general, the UK modular industry is regulated by the same codes as conventional construction (Modular Building Institute, 2019). A recent study was undertaken by the British Standards Institution (BSI) to examine how existing standards need to be updated and the development of new standards to meet industry requirements for off-site construction (BSI, n.d.). It was identified that while there are some standards (international, European, British and industry) that are used for the design and construction of off-site constructions, they tend to be out of date or limited in scope. The study identified four broad aspects that need to be addressed:

- Design: A standardised procedure is necessary to assist with this phase and to take into consideration aspects which are unique to off-site construction, including: types of off-site systems, transportation and installation, the extent of disclosure of intellectual property (IP), demonstration of compliance at different stages, and considerations about maintenance and repair.

- Accuracy and tolerances: Updating standards addressing tolerances as currently they do not consider improvements in manufacturing accuracy, increased measurements and surveying equipment capabilities.
- Integration and connections: A method to deal with the difficulty in integrating different materials, systems, and/or modules from different suppliers into a common building.
- Technology and knowledge sharing: Developing consistent set of standards and use of terminologies.

3.6 New Zealand

New Zealand, similar to Australia, is also looking to expand its prefabricated housing market and is facing similar challenges. BRANZ has initiated research to investigate how to improve the NZ compliance and assurance frameworks for manufactured buildings (Chang-Richards et al., 2019). The study highlighted the importance of establishing a chain of custody across the supply chain where all stakeholders (e.g., designers, manufacturers, suppliers, builders, and building consent authorities) take their due diligence. Clear regulation is required to define the responsibilities of importers and manufacturers/suppliers to assure the performance of imported products.

The general product assurance framework adopted in New Zealand is shown in **Error! Reference source not found.**. It is the responsibility of the manufacturers and suppliers to provide evidence that the product is fit for purpose. Like Australia, third-party certification (e.g., CodeMark, BRANZ and ISO) is voluntary in New Zealand and therefore there is lack of incentive for manufacturers to get costly certifications.

In 2010, the Ministry of Business, Innovation and Employment (MBIE) introduced a national multi-purpose approval, known as Multiproof, to streamline the consent process for standardised designs and enhance the compliance process for prefabricated buildings with the Building Code. However, the research undertaken by Chang-Richards et al. (2019) showed that industry professionals suggested that the approach required more flexibility and efficiency.

More recently, New Zealand is in the process of introducing a new Bill for the voluntary manufacturer certification scheme for modular component manufacturers (MCM) (New Zealand Government, 2021). The scheme will allow manufacturers to be certified to produce building component and modules and assesses the overall process as necessary, including manufactures, assembly, transportation, on-site installation to ensure compliance with the requirements of the building code. The certification involves third-party inspections, audits and post-certification surveillance will to ensure quality of construction.

4 Stakeholder consultation

Consultation with various stakeholders has been undertaken in the form of online surveys and one-on-one/group interviews and meetings. Written submissions have also been provided by some of the stakeholders.

A total of 286 participants completed the online survey and individual discussions with more than 20 participants have been undertaken.

All invited participants were provided a Briefing Paper which provided background information and identified key issues and questions related to prefab and modular construction which had been identified by the project team.

The stakeholders that have been consulted to provide their opinions and experiences include:

- Builders (main contractors) involved in installing/assembling prefab/modular buildings
- Design engineers and architects
- Prefab/modular manufacturers and suppliers
- Sub-contractors (e.g., mechanical, electrical, or plumbing service works)
- Building surveyors, inspectors and local authorities
- Industry associations
- Researchers

4.1 Surveys

Participants were invited to provide feedback via completing an online survey or providing written submission in response to the Briefing Paper. In total, 286 participants completed the survey. All written answers to questions were optional. The survey had 28 questions in total. The survey questions and a summary of the responses are provided in Appendix A. A summary of the type of organisation or work that the participants associated themselves with is shown in Figure 7.

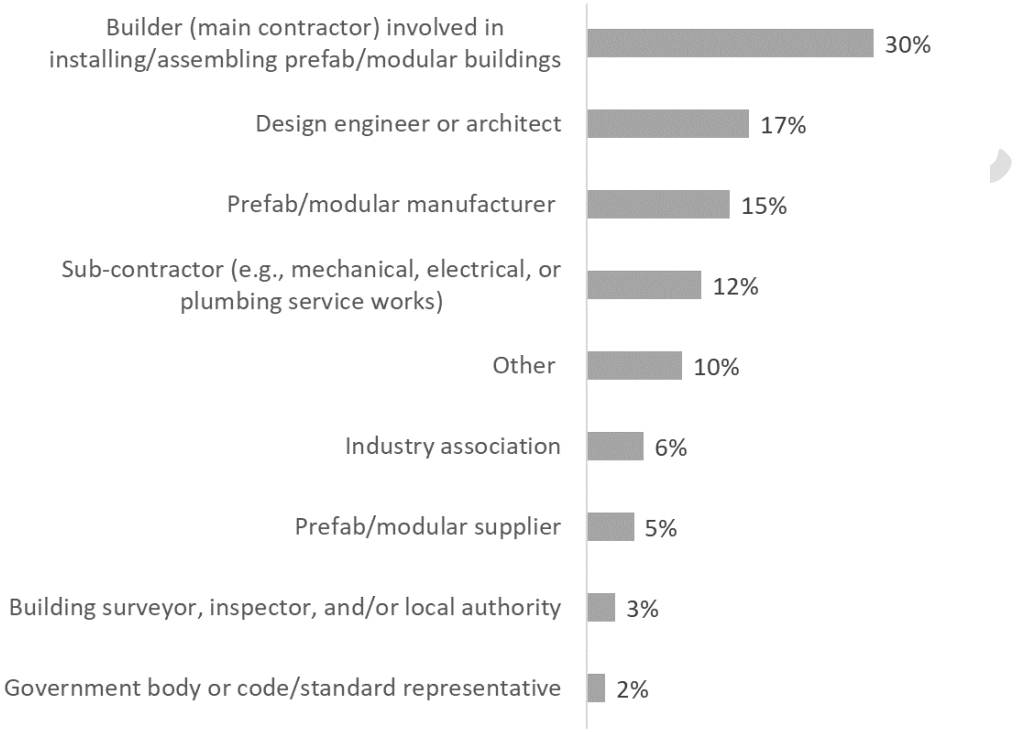

Figure 7: Participants involved in the survey

4.2 Interviews and meetings

Semi-structured interviews and meetings have been undertaken with discussion related to:

- The scopes and limitations of planning and building regulations on off-site construction particularly in residential construction.
- The differences in planning and building approval processes for on-site and off-site construction.
- Suggestions on what changes are needed in this space (if any).

In total 17 interviews and meetings have been conducted with 23 participants. A summary of the participants is shown in Figure 8. The selection of the participants was based on their type of expertise and familiarity with off-site construction. The aim was to include various stakeholders involved in the supply chain.

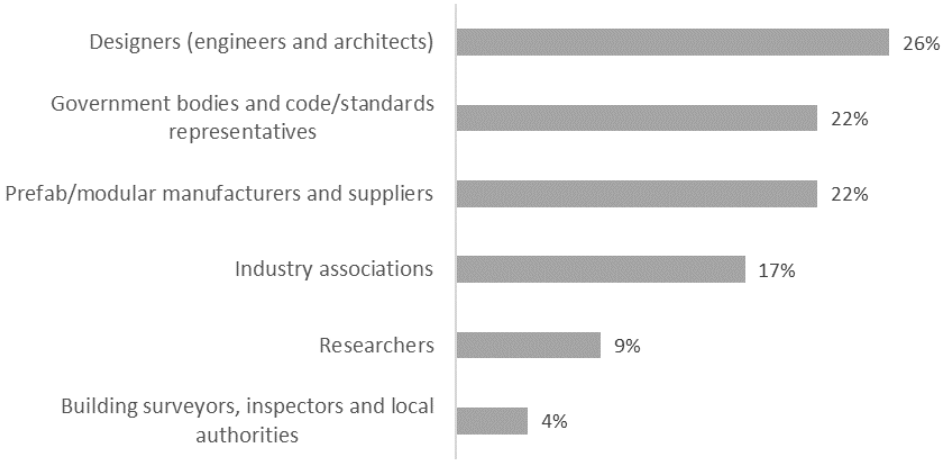

Figure 8: Participants involved in the interview and meetings

4.3 Summary of findings

In total, seven key areas were identified from the online surveys, interviews/meetings, and written submissions, that require support to assist with the uptake of off-site construction:

(i) Definitions
(ii) Town planning
(iii) Design guidelines
(iv) Compliance and quality control
(v) Supply chain responsibilities
(vi) Finance
(vii) Incentive, familiarity and experience

Each of these is described in more detail in the following subsections.

In general, it was observed that participants would like to see improvements to existing planning and building regulations to help with the uptake of prefab and modular construction. This was evident in the survey response shown in Figure 9, with 68% of participants agreeing that some form of change or improvement is necessary for planning and building codes and Australian Standards.

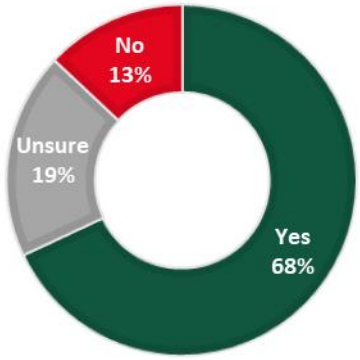

Figure 9: Survey response to "Do you think any improvements/changes need to be made to existing planning and building codes and Australian Standards to assist with the uptake of prefab and modular buildings?"

4.3.1 Definitions

The general feedback from all participants was that there is a need for clarification of definitions and consistent use of terms. This is in terms of both the **type of prefab** that is for example if dealing with 2D panels or 3D volumetric modules and the **level of prefab** as in the extent of prefabrication including if structural elements are open or enclosed (i.e., hidden) and what other components are included such as mechanical, electrical, plumbing, and finishes.

The importance of definitions especially for the level of prefabrication was observed in response to the survey question asking if we should promote the use of a fixed set of definitions based on the level of prefabrication for technical and regulatory use, with 67% of participants agreeing that this is necessary, see Figure 10.

It's noted that in prefabricated components for which the structural members are not enclosed (such as trusses and frames), there are no regulatory barriers, especially if a deemed-to-satisfy (DTS) solution applies. The regulatory environment starts to struggle with enclosed components (e.g., wall panel or floor cassette) where it is not possible to see and examine all the necessary components. This is also when certification becomes difficult as it is unclear how the component has been manufactured.

The other issue that was raised was around the numerous terms used for off-site constructed buildings (e.g., manufactured home, movable home, relocatable home, temporary structures, kit homes, manufactured home estate) and confusion about when the NCC applies and lack of consistencies between states and territories.

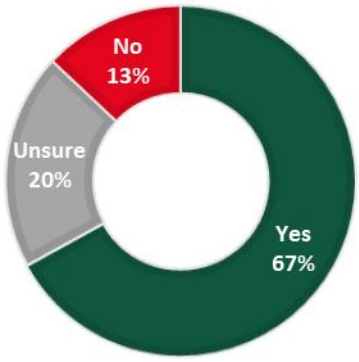

Figure 10: Survey response to "Do you think we should promote the use of a fixed set of definitions based on level of prefabrication for technical and regulatory use?"

4.3.2 Town planning

Generally, a mixed response was observed about town planning issues. Some participants noted that there were no additional barriers or challenges in relation to prefabricated and modular buildings whereas others raised concerns. Some participants stated that the state and council are hesitant to provide approvals for new concepts which can cause very long delays.

It was also noted that both off-site and on-site construction face similar challenges when the final resolution to achieve sign-off is prolonged. However, for on-site construction, this issue can usually be resolved through the building approval documentation stage while the site preparation works are in progress. Whereas, for off-site construction, the delays become a significant issue as site preparation and construction of building/building components take place simultaneously.

4.3.3 Design guidelines

Many participants noted that the NCC and most design standards have been written with on-site construction in mind and therefore it is difficult to apply all of the current requirements for off-site construction. Some participants noted that there is a need for a comprehensive and user-friendly

document to provide guidance for prefab and modular construction and to ensure that it is acknowledged by NCC as a reference document.

The following are examples for which a prescriptive form of guidance is needed:

- Loads to be considered for transportation (temporary loads).
- How to maintain rigidity of components during lifting and transportation.
- Precision and tolerance requirements.
- Connection and integration requirements, describing how the prefab/modular component connects to each other and to the rest of the building.

It was discussed that guidance may be necessary for each construction material (e.g., concrete, timber, and steel) and composite materials. It was also noted that some materials are covered better than others, e.g., precast concrete. Overall, guidance may be provided based on the building class (low rise versus mid- and high-rise buildings), the type of prefabrication (2D and 3D), and the level of prefabrication (i.e., component with exposed structural elements such as a truss or wall frame versus a component with structural elements and services and finishes).

Furthermore, in general, it was noted that the Handbook by the Modular Construction Codes Board (MCCB) provides good general information about modular buildings, however, more specific and detailed guidance is necessary. This was also reflected in the response to the Survey Question concerning the level of support provided by the Handbook, shown in Figure 11. 71% of participants responded either as neutral or not enough support is provided by the handbook. Many participants also noted that they were not familiar with the Handbook.

Another issue that was raised was about repairs and maintenance post-occupancy. Repair work for a prefab/modular constructed building may be different from on-site, for example, a critical wall component or connection may not be easily replaced or modified.

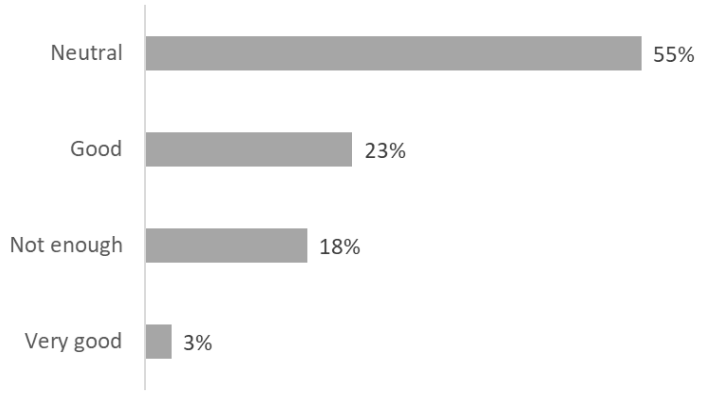

Figure 11: Survey response to 'What level of support does the Handbook for modular structures by the Modular Construction Codes Board provide?'

4.3.4 Compliance and quality control

Compliance and quality control were one of the key themes that were discussed in the interviews and questioned in the survey. To some extent, a mixed response was observed about compliance

challenges for prefab/modular construction. This was also apparent in the survey question which asked about the effectiveness of the current method to demonstrate conformity and quality control, shown in Figure 12. Around 61% of the participants responded as neutral, 20% as good/very good, and 18% as bad/very bad.

The mixed response highlights the need for guidance and a standardised process as some seem to be facing limited challenges while others are facing great barriers. Furthermore, in general, it was noted by the majority that the regulations have been written for on-site construction. In particular, the approval process and the role of the inspector are based on on-site activities, e.g., for on-site construction inspection is required on completion of framing work. There is a need to clearly define the approval process for off-site construction based on different levels of prefabrication.

It was noted that currently, the approval of a complex building product is done at the end after the product has been manufactured and installed on-site. Hence, after the building has been constructed, it is possible to have issues with compliance approval. Therefore, manufacturers and builders are reluctant to uptake modular construction due to the increased risk.

In addition, the challenges related to performance solutions were also highlighted, and currently, the process applies to a specific job. It was suggested that two forms of performance solutions are necessary:

(i) One-off approval for a specific job, this should be relatively simple since the risk is lower,
(ii) Generic approval which is not limited to a specific job/site, has a higher risk, and hence the process is likely to be more stringent than 'one-off' approvals.

Furthermore, it was noted that currently there is no guidance on quality control, this is a general problem for all construction products and is not yet addressed in the NCC. Quality control systems must cover compliance with all the necessary performance requirements for each component of a system.

It was discussed by some that it is preferable and practical to have a process such that the source of the product does not matter (i.e., overseas products can follow the same procedure). Currently, there are also different rules in different states and territories which also mean that a product that is accepted in one state (e.g., Victoria) may not be accepted in another (e.g., Western Australia). Nevertheless, it was noted that it is important that the process for compliance is not too complex or expensive. Some participants expressed concerns that currently, the cost of compliance is too high.

It was also highlighted that good documentation of products used in buildings, including prefab/modular components is critical. It is necessary to know exactly what has been included in a building, especially for future changes and demolition.

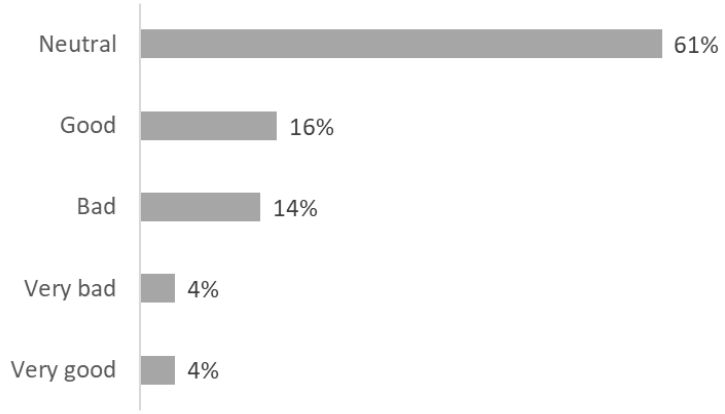

Figure 12: Survey response to "How effective do you think the current method to demonstrate conformity and quality is?"

4.3.5 Supply chain responsibilities

In the interviews and meetings, it was highlighted that there is a need to clearly define the responsibilities of the supply chain with prefab/modular construction in mind, which in turn will assist with understanding the regulatory requirements. This was also observed in the survey, with 48% stating the role and responsibilities of stakeholders are not clear for prefab and 30% stating that they were unsure (see Figure 13).

It was suggested that the supply chain responsibilities need to be spread across all those involved including the manufacturer and builder. Some participants stated that currently if something goes wrong with a building most of the responsibility lies with the engineer, building surveyor, and certified electrician/plumber. For example, under the licensing regime, the electrician/plumber who is undertaking the installation/connection is responsible to approve the final product and is, therefore, reluctant to do so with prefabricated products. It is noted that while the product can have a Watermark, these are typically componentry and it does not mean the system is okay or fit-for-purpose. In contrast, some participants noted that there are not facing any issues, particularly for residential construction where the plumbing and electrical systems are all 'plug and play' and certification is provided by the plumber/electrician by checking on-site after installation.

Issues were also raised about post-occupancy such as problems associated with repairs and maintenance and warranty conditions. It is unclear how these issues are to be handled

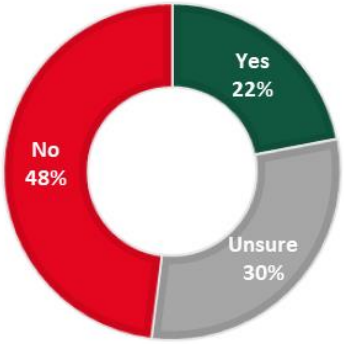

Figure 13: Survey response to "Do you think the responsibilities and roles of stakeholders in the supply chain for prefab are clear?"

4.3.6 Finance, deposits and stage payments

The issue of finance consistently came up during the consultation even though it is not directly related to regulations. It has been highlighted to be one of the main barriers to prefab/modular construction. It includes challenges associated with obtaining bank guarantees and high premiums for insurance.

Furthermore, for high-level prefabricated products, most of the work is done off-site, and therefore the current method for houses is based on progress payments after inspection of key stages (e.g., excavation for foundations, foundation construction, frame, and truss installation, and completion) are not suitable.

A new system is necessary for when inspections need to take place and when payments need to be made. Currently, only large companies can handle the financial risk associated, including short-term risk related to cash flow and long-term risk of something going wrong and needing insurance cover.

4.3.7 Incentive, familiarity and experience

The consultation revealed that, in general, there seems to be very little incentive for the uptake of off-site construction. This is both due to insufficient awareness of the potential benefits as well as lack of demand in Australia.

In addition, since most large builders have not taken up prefab and modular construction, this form of construction is not very accessible, and consumers are not well informed.

It was also highlighted that the industry at this stage is not necessarily capable of dealing with modular construction due to insufficient technical knowledge and support, and a clear understanding of how to achieve compliance and quality assurance

Participants noted that government support and incentives are required to encourage the development of prefab/modular construction. Also, educational campaigns are necessary to inform people of the potential advantages of off-site construction.

One key area where prefab and modular construction can provide great support is post disasters such as bushfires and floods due to the speed of construction which it can provide and reduce demand for on-site labour. Furthermore, it is necessary to upskill and educate the industry so that there is greater familiarity with prefab and modular construction. It is noted that this is subject to a separate projects through the Prefab Innovation Hub.

5 Recommendations & implementation options

Draft Recommendations:

Recommendation 1 – That prefabrication and modular construction be explicitly recognised as regulatory acceptable construction practices.

The lack of formal regulatory recognition has been identified as a major barrier to the development of this form of construction. On-site construction was a traditionally defining characteristic of the building industry as distinct from the manufacturing industry. The building regulatory system was largely constructed on this basis. This is the major cause for the perception of increased risks for all parties in this form of construction.

Recommendation 2 – That a standardisation of terms and definitions for prefabrication and modular construction activities be established for use in Australia.

Definitions are necessary to describe the level of prefabrication (e.g., if structural elements are open or enclosed (i.e., hidden) and what other components are included such as mechanical, electrical, plumbing, and finishes) and the type of prefab (2D panels or 3D volumetric units). Definitions are also required to describe off-site constructed buildings, (e.g., manufactured home, movable home, relocatable home, kit homes, manufactured home estate) particularly in the regulatory context.

Recommendation 3 – That planning requirements for prefabrication and modular housing be –

(a) amended to explicitly recognised prefabrication, modular and tiny homes as acceptable forms of housing; and
(b) reviewed to identify where hindrances exist and to consider means to streamline approvals

Planning schemes need to be reviewed and amended to acknowledge prefabricated, modular and tiny homes as the lack of formal regulatory recognition has been identified as a major barrier to the acceptance and approval of this form of construction. This is the major cause for the perception of increased risks for all parties in this form of construction.

Recommendation 4 - That the Australian Building Codes Board (ABCB) establish a project to identify ways to provide prescriptive and performance requirements into the National Construction Code (NCC) to support the orderly use and approval of prefabrication and modular construction for Class 1 buildings.

The National Construction Code (NCC) is Australia's primary set of technical design and construction requirements for buildings. The NCC has traditionally been drafted for convention construction and construction methods.

Whilst the NCC is a performance-based code, meaning the NCC presently can enable the use of innovative forms of construction via development of Performance Solutions to meet the code. However, this pathway is variable in potential acceptance and presents challenges for manufacturers in bringing new products and systems to market and can be costly and time consuming.

Furthermore, the NCC's Performance Requirements are generally drafted in qualitative language meaning it is very difficult and can result in significant inconsistency in what a product or system may need to meet to satisfy the approval body for the project.

This recommendation seeks for the ABCB who produces and maintains the NCC, to establish a project on their work program to review the NCC provisions in how they would apply to modular and prefabricated construction and to develop new DTS Provisions and Performance Requirements specifically for modular and prefabricated construction to support their orderly use and approval of prefabrication and modular construction for Class 1 buildings.

This recommendation is of particular importance to low-rise residential construction that rely on DTS provisions for its regulatory acceptance.

Recommendation 5 - That Standards Australia develop a work program to–

(a) review and modify the relevant construction standards particularly NCC referenced standards for their adequacy to cope with Prefabricated and Modular construction; and
(b) develop a new suite of Australian Standards specifically for Prefabricated and Modular construction to provide industry with DTS construction solutions

Standards Australia is a key component of Australia conformance infrastructure. This recommendation is of importance to low-rise residential construction that rely on DTS provisions for its regulatory acceptance.

Recommendation 6 - That the current Australian product conformity infrastructure be reviewed for its ability to cope with new prefab and modular products that need testing as the basis for their acceptance.

This includes review of CodeMark and the National Association of Testing Authorities (NATA) for conducting tests and providing certifications for innovative products, including prefab and modular components.

Recommendation 7 – That comprehensive design guidelines for prefab and modular construction be developed to address elements that are different from on-site construction.

This may include work that is required to be performed, supervised, and/or signed off by licensed practitioners. These guidelines could be introduced into the system as new standards or additions to existing standards.

Recommendation 8 – That a manufacturer quality management scheme be recommended to suit the specific needs of the prefab and modular building industry.

There is a need to ensure that products from off-site manufacturing are consistently used in accordance with their design specifications. A specified voluntary scheme (like the Bill that is to be

implemented in New Zealand to allow a new voluntary manufacturer certification scheme for modular component manufacturers) has been suggested as an effective way forward. The building surveyor/certifier still has the final check of the product on-site.

Recommendation 9 – That the industry is upskilled by setting up specialist courses for prefab and modular construction.

This will serve the dual purpose of: (i) improving national capability and (ii) increasing awareness among building surveyors/certifiers, engineers, architects, and builders for this form of construction.

Recommendation 10 – That a building industry taskforce is set up to further investigate and address barriers associated with contracts, progress payments, licening, mandatory stage inspections and insurance .

While this is not within the brief of this project, a range of related regulatory and quasi regulatory barriers have also been identified that this taskforce could be tasked with:

(i) Reviewing state & territory building laws and develop a new tailored progress payment arrangement for building contracts for modular and prefab construction to act alongside the progress payment arrangement for conventional construction

(ii) Reviewing and state & territory building laws and develop a new tailored arrangement for staged building inspections throughout the construction process, for those states with mandatory construction stage inspections in place, for modular and prefab construction taking account of differences and to act alongside on arrangements for conventional construction.

(iii) State and territory licencing requirements particularly those states with trade contractor licencing have been developed to reflect works carried out for conventional construction. State & territory licencing laws should be reviewed and expand the existing classes of licences for those parties working on modular and prefab construction.

Other related non-regulatory but barriers to use and acceptance of modular and prefab construction nonetheless includes difficulties to obtain a bank guarantee if it's prefab & modular construction higher insurance premium for prefab and modular design and construction.

The taskforce should look at what other improvements could be made to address these matters.

Recommendation 11 – That the Australian governments provide incentives and support by encouraging increased use of prefab and modular construction in their procurement specifications.

The benefits of such policy include: (i) providing manufacturers with more projects to recover their initial setup cost, (ii) more builders will transform their practice to be able to participate, (iii) more research and development activities in innovation and smart technologies.

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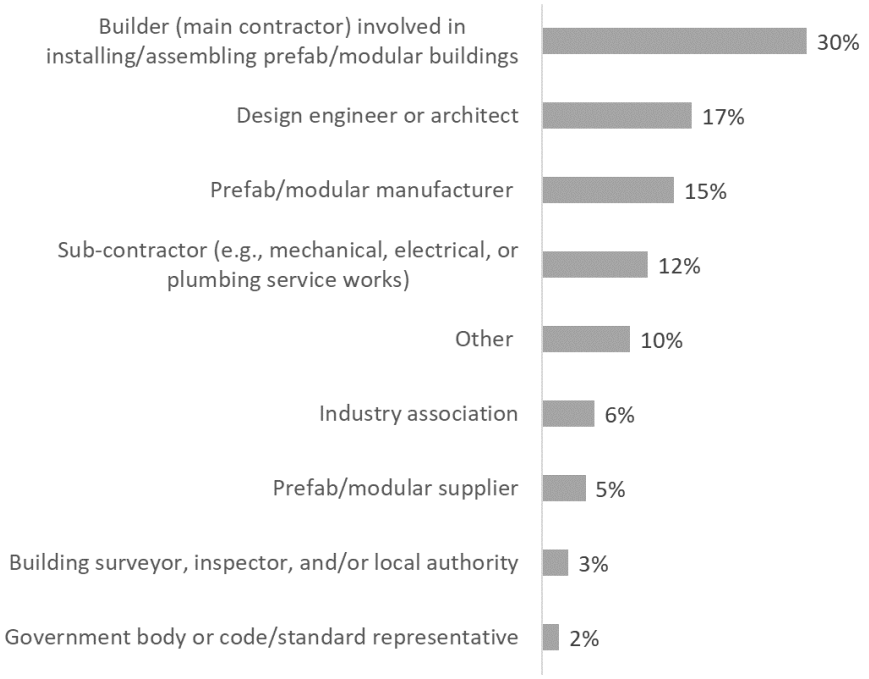
Appendix A: Summary of responses to survey questions

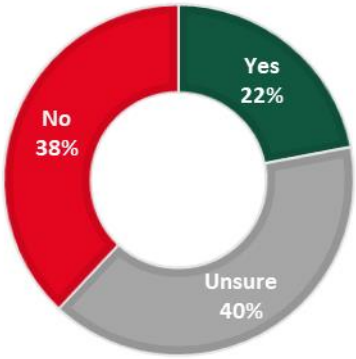
1. **Which type of organisation/work do you associate yourself with?** (You can select one or more options)



'Other' included:

- Academic
- Builder of non-prefab
- Carpenter
- Construction manager
- Contract administrator
- Customer
- Developer
- Draft person
- Energy efficiency consultant
- Estimator
- Precast concrete manufacture and erection industry
- Town planner

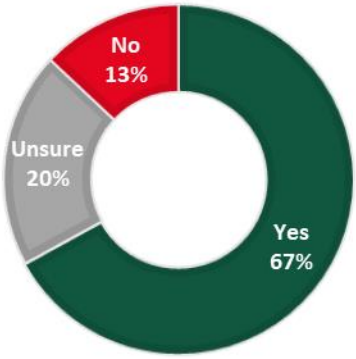
2. **In relation to prefab and modular construction, do you have preferred terms to be used for regulatory purposes?** (Yes, No, Neutral) If yes, please explain.



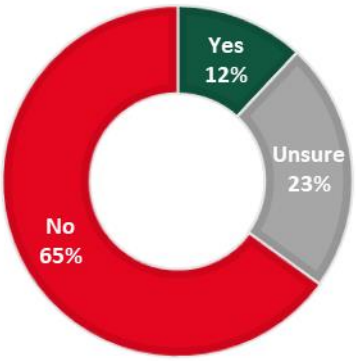
Participants responded that it would be good to use terms with clear and accurate definitions that are applied to all Government regulations. The terms should take into account the level of prefabrication, for example, prefabricated concrete wall panels versus prefabricated homes that are delivered to the site ready to plumb, with electrical connection, and ready to go. Some participants also highlighted that the terms should also consider the delivery, quality assurance process, and efficiency. It was also highlighted that the terminology used distinguishes between 2D and 3D volumetric components. It was noted that prefab is used in reference to off-site manufactured panels, systems, and components whereas modular is the term used for volumetric construction. Some respondents also noted the difference between prefab, panelise, and modular, where prefab is commonly used for wall frames & roof trusses, panelised is used for wall panels (open/closed) or floor/roof cassettes, and modular is used as volumetric modular.

The terms in relation to the type of off-site constructed buildings were also discussed. Namely, the different terms available in Queensland and New South Wales. It was noted that in QLD, the term "Modular Building" is used which is deemed as a Class 1a Single Dwelling house for the Planning Act and does not affect the use of the building for compliance purposes. However, in NSW from the NSW Home Building Act 1989, the available terms are "Kit-home" or "Manufactured home" which do not accurately define the product that some manufacturers are producing. For example, a manufacturer can provide a dwelling house constructed in a factory, separated into modules, shipped, and re-assembled on the chosen site. These manufacturers believe that NSW does not obtain a current definition for this type of building work and hence creates difficulty in obtaining compliance for what should be considered as a dwelling house.

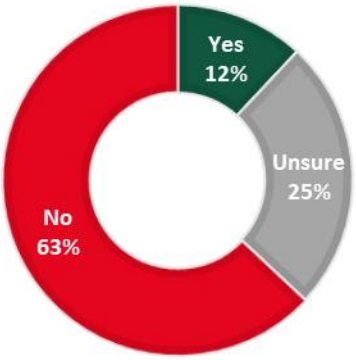
3. Do you think we should promote the use of a fixed set of definitions based on the level of prefabrication for technical and regulatory use? (Yes, No, Neutral)



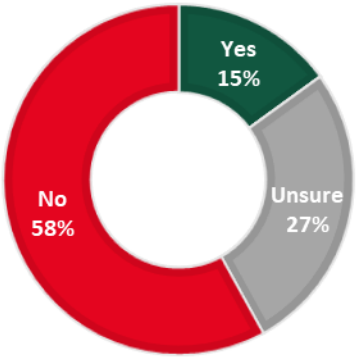
4. Are you aware of any research on regulatory issues in Australia as a barrier to the development of the prefab industry? (Yes, No, Neutral) If yes, please explain.



5. Are you aware of any regulations from any country specifically designed for the prefab industry that could be introduced in Australia? (Yes, No, Neutral) If yes, please explain.



6. Are you aware of any schemes from any country that facilitate the prefab industry and could be introduced in Australia? (Yes, No, Neutral) If yes, please explain.

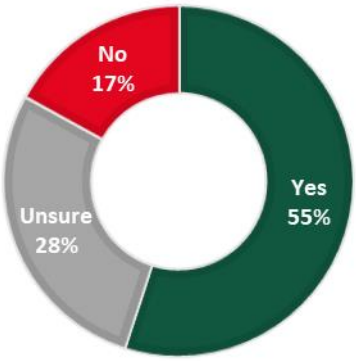


Participants highlighted a few countries/regions with schemes that may be suitable for Australia, including the UK, Europe (specifically some noted Germany, Northern Europe, all of Europe), the USA, Canada, and Vietnam. In particular, the schemes available in the UK were discussed, including the Modern Methods Construction (MMC) bill. It was highlighted that the UK Government has introduced new specifications/criteria which prefer builders of government construction projects that adopt modular/prefab design in their buildings. The Australian Government should consider increasing incentives/funding to promote extensive investment in technology in this area but needs to tackle the building code changes that are necessary to improve the efficiency and practicality of modular construction.

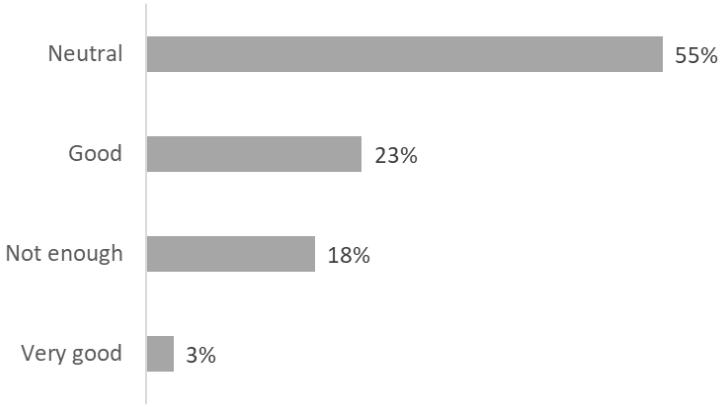
Furthermore, for finance, it was suggested that the work that Offsite New Zealand has done for negotiation with Westpac is a good example for Australia.

It was also noted that some South American countries have seen modular design and construction methods used in conjunction with economic schemes. The housing infrastructure is partially resolved with technical details that allow the buildings to be easily developed in the future.

7. **In lieu of changing or making new regulations – is better use of current regulations and more guidance and supporting tools the answer?** (Yes, No, Neutral)

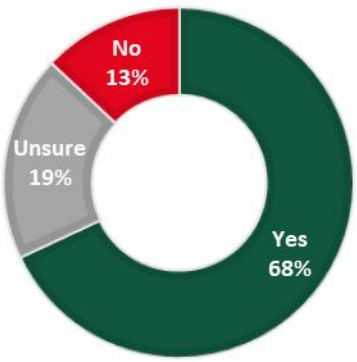


8. **What level of support does the Handbook for modular structures by the Modular Construction Codes Board provide?** (Very Good, Good, Neutral, Not enough) Please explain your rating.



In general, it was noted that the Handbook by the MCCB provides good general information about modular buildings, however, it was noted that it could be expanded. It was highlighted that details are required to address planning barriers and risk-averse culture in Australian urban growth. Furthermore, the Handbook could be improved by cross-referencing to or correlating with the NCC, as well as providing case studies with respect to the application of the NCC to modular construction. Furthermore, many respondents noted that they were not familiar with the code.

9. **Do you think any improvements/changes need to be made to existing planning and building codes and Australian Standards to assist with the uptake of prefab and modular buildings?** (Yes, No, Neutral)



The following questions are in relation to the <u>regulatory acceptance process:</u>

10. **In your opinion, what are the key differences in regulatory compliance between on-site and off-site construction and do you think there are 'grey' areas that require clarification?**
The following key points were raised about the key differences in regulatory compliance between on-site and off-site construction:

- Planning issues. Participants highlighted their challenges with local town planning, especially as every state and council is not willing to approve any new concepts promptly whereupon delays exhaust enthusiasm to giving up.

- Inspection and approval process. For a closed panel system, it is not possible to complete a framing inspection on site. It is also difficult to complete in the factory because generally, only one panel will be under construction at any point in time. Similarly, an inspection of services is difficult when they are hidden in walls, etc, and becomes more challenging when the product is built in a different local authority to the site where it's going to be installed. It was noted that if the mandatory stage inspections can be satisfactorily undertaken both within the pre-fabrication process and on-site, the regulatory framework can remain similar and compliance with the same building codes for prefab and on-site construction can be achieved.

  Some also note that modular projects currently appear to get around traditional legislation and that specific legislation is required to rectify this issue. It was suggested that a new type of inspector is required during construction that can certify each as-built building (engineers and certifiers) in the factory and then re-certify once on site.
- Demonstration of compliance. This is especially a concern for higher-level prefabricated products. It was noted that there is insufficient detail and testing of products coming to the market. Some modular home manufacturers highlighted that they do not seek any exemptions to the current codes and that there should be little, if any difference, in the final product performance. Regulatory compliance for off-site construction is challenging when it comes to innovation as some stakeholders do not know how to deal with the different construction methods. Other participants suggested that the difference between off-site and on-site is minimal, especially if the off-site construction works are certified in line with engineer detailing or Australian Standards.

- Benefits of energy efficiency not completely realised. Nature of energy efficiency compliance, smaller homes have smaller energy usage and the potential to be fully off-grid. The standard JV3 and DTS methods of assessment may not fully appreciate the nature of these homes being more energy-efficient.

Furthermore, the challenges associated with finance were raised. Current progress payments are suitable for on-site construction work. It is difficult to get funding when there is no physical asset on-site.

The following specific points were raised in terms of design:

- Fire compartments are difficult to achieve.
- All buildings should be built to the highest wind loading to allow relocation without constraint.
- Challenges with clearance heights, the natural ground level (NGL) to the first structural member is difficult to achieve NCC compliance.

The following recommendations/suggestions were also provided:

- Better use of BIM CAD tools for virtual inspections and compliance photos/processes in the factory are options to improve quality assurance.
- A separate section needs to be introduced with Safety in Design requirements since most of the construction work is done in a factory environment.
- Essential to maintain 3rd party certification including for on-site work.
- Certification of the end product will need to be more comprehensive as compliance and checking off-site prior to transportation is not an option.
- Suggestion to have a NCC volume 4 for modular construction, and that one code not numerous standards would be easier to deal with.
- Off-site construction needs to follow a manufactured product approach. Typically, the quality of the product is higher because built in a factory-type environment. For on-site construction, the quality is highly variable depending on the day and personnel involved. The level of supervision also seems to be lower for on-site.

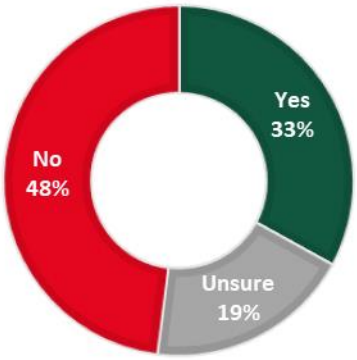
11. How long does the regulatory acceptance process take for prefab/modular buildings and how does this compare with conventional buildings?

    A mixed response was observed for this question. Some participants stated that there was little or no difference between on-site and off-site homes in terms of compliance time and the number of hurdles. Whereas, other participants noted that the process is significantly longer for off-site construction. A participant noted that it can be nearly three times as long due to town planning issues caused by inexperience and fear to approve this kind of work, and that it is not unusual to wait two years and go to arbitration. Some also noted that both off-site and on-site face similar challenges when the final resolution to achieve sign off is protracted. However, in on-site construction this issue can usually be resolved through the building approval documentation stage whiles the site preparation works are in progress. Whereas, for off-site construction, since these construction activities are concurrent rather than in a linear sequence, the delays become an issue.

    Specifically, it was noted that in NSW, the regulatory compliance framework does not support modular buildings under the provisions of the State Environment Planning Policies (SEPP). Therefore, the Local Government local environmental plans (LEP)/development control plans (DCP) provisions are sought for compliance where most Local Government (LG) provisions do not include the term 'Modular Building' and therefore fall into a 'Miscellaneous' category of a 'Section 68' assessment. This can cause a myriad of issues that relate to the permissible use of Modular Buildings within the LG area and the inability for a specific framework to be assessed against. It was noted that without these mechanisms, builders/designers are finding it hard to properly plan and design a complaint dwelling for both clients and contracts. It was suggested that a specific SEPP statute is passed for modular/prefab homes to assist with regulatory compliance of modular houses.

12. Have you had experiences with projects using modular or prefab construction that have been unnecessarily hindered by planning or building regulation? (Yes, No, Neutral). If yes, please

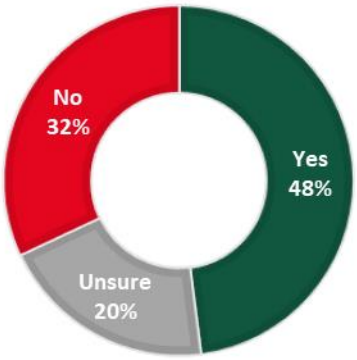
explain your answer.



The participants that answered 'yes' to this question noted the following issues with planning and building regulations:

- Development of a suitable fire resistance level (FRL) performance solution for Type A construction.
- Concerns with having the installation determined as temporary and not needing fire hydrants installed throughout the development as it was argued that the buildings were hard-wired, connected to sewer/water, and welded to the foundation, thus making it permanent.
- Concerns with different types of external finishing systems. For Victoria, it was noted that there is a lot of focus on external facades which increases the project cost.
- Approval panel not familiar with the modular process. Some participants noted that they build in a lot of remote areas and some councils need more information to gain an understanding that it is not a caravan, however, this is usually easily navigated through to approval.
- Due to the speed of construction, the local government was too slow in approvals.
- Specific issue in NSW was raised again that the regulatory compliance framework does not support modular buildings under the provisions of the SEPP. Therefore, the Local Government LEP/ DCP provisions are sought for compliance where most LG provisions do not include the term Modular Building and therefore fall into a Miscellaneous category of a "Section 68" assessment.

13. **Do you think factory sign-off could be used as a solution, including factories not located in Australia?** (Yes, No, Neutral)



14. **How do you think the regulatory acceptance process can be improved for prefab/modular buildings?**

The following improvements were suggested by the participants:

- **Planning.** To change planning provisions that allow developers to put 'no prefab' caveats on estates.

- **Building code and standards.** Some participants noted that they would like the development of new codes and standards that are specifically for prefab and modular constructions. Many of the standards are developed internally at significant cost, it would be great to see the industry cover off-site considerations in terms of areas outside of on-site construction. An example is transport, whilst there are standards for transport it is not readily known how to apply these to off-site construction, many transport operators are not aware of how to determine the best practice for moving large custom elements.

  It was also highlighted that whilst a regulatory environment such as the NCC is performance-based, it still does not sufficiently recognise the project delivery methodology and provide for acceptable alternative pathways to achieve a performance outcome. This results in frequent site-specific custom solutions and the inherent cost of development. In contrast, some participants stated that modular dwelling houses can still comply with all deem-to-satisfy provisions of the NCC and that there are no issues to address.

- **Certification and approvals.** Some suggested that the factor should provide a certificate of compliance while others stated that certifiers should attend the factory to provide approval prior to transportation. It was also noted that an introduction of a regulatory mechanism where the manufacturers can attain accreditation of standardised prefab/modular systems as meeting a range of NCC requirements could be useful.

Furthermore, bulk compliance based on audits and 'product testing' post-construction was also suggested. It was noted that predominantly these are production line manufactured buildings and they should have an updated regulatory process to better suit this type of manufacturing.

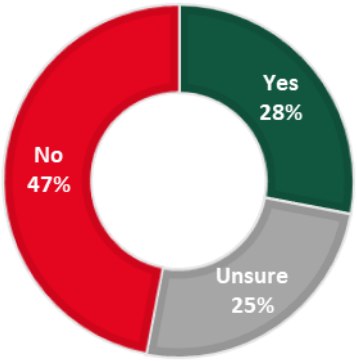
Concerning imported products, it was highlighted that a greater level of scrutiny is required for inferior prefabricated buildings.

- Finance.
  It was noted that the government needs to amend the contracts Act to support builders financially so that they do not have to fund projects upfront.

- Education.
  Regulators to become more familiar with off-site construction. Furthermore, changing the generally negative perceptions of off-site construction and educating people about the advantages.

The following questions are in relation to building codes and standards:

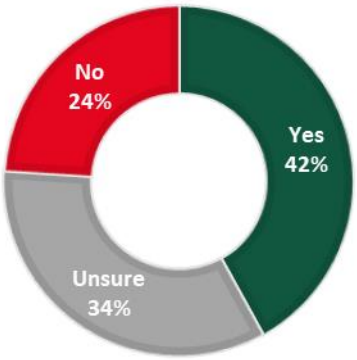
15. Do you think that current planning and building codes are difficult to apply for prefab and modular buildings? (Yes, No, Neutral). If yes, please explain your answer.



The following responses were provided for the participants who agreed that current planning and building codes are difficult to apply for prefab/modular buildings:

- Difficult with planning, especially the NSW problem as stated previously.
- Difficult to show compliance even though the system performs better than the traditional method.
- Harder to achieve energy star rating due to floor disconnected from the ground.
- They have become too difficult to apply to building in general, the regulatory system needs to be reviewed for efficiency and suitability for purpose.
- They are hard because the BCA is hard. It keeps people safe and should not be watered down.

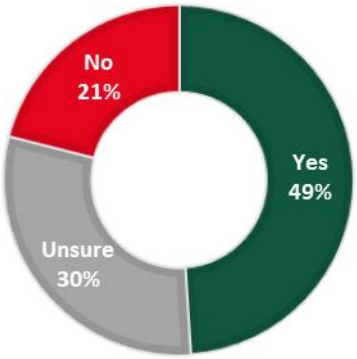
16. **Do any improvements or changes need to be made to existing Australian Standards or should there be specific Australian Standards developed for modular and prefab construction?** (Yes, No, Neutral). If yes, please explain your answer.



The following responses were provided for the participants who agreed that changes need to be made to existing Australian Standards for modular and prefab construction:

- A code for modular construction would make approvals easier.
- A specific Australian Standard would help to show that the industry has a national acceptance level. It was also noted that the standards need to be updated to keep up with technology.
- Consideration of renovations.
- Allow for international suppliers.
- There need to be real compliance verifications throughout the building process, using independent personnel.

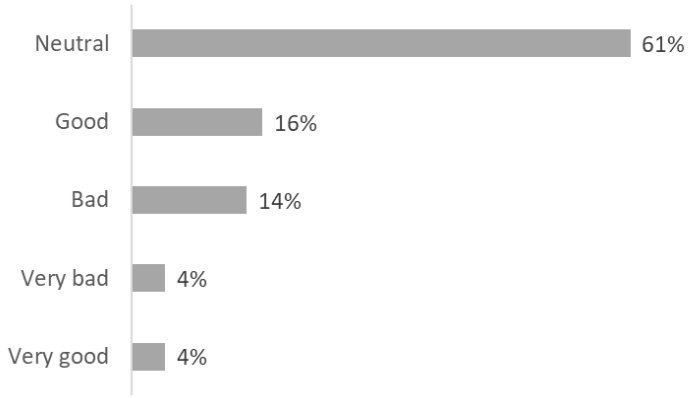
17. **Should the NCC have a dedicated Section dealing with prefab and modular buildings or should this be left to Performance Solutions?** (Yes, No, Neutral).



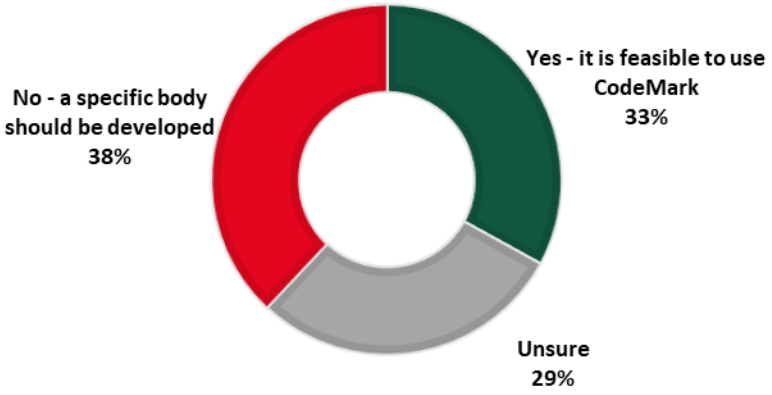
18. **What method do you use, or do you think is used, to demonstrate conformity and quality assurance? (e.g., self-certification, third-party independent product certification, factory and production certifications, traceability measures such as product identification methods).**

A mixed response was observed for this question. Some participants noted that all forms of demonstration of conformity and quality assurance (the examples provided in the question) are necessary, while others note specific ones, including a combination of self and third-party certification, factory and production certifications, independent audits, internal factory quality assurance processes and certifications by qualified engineers.

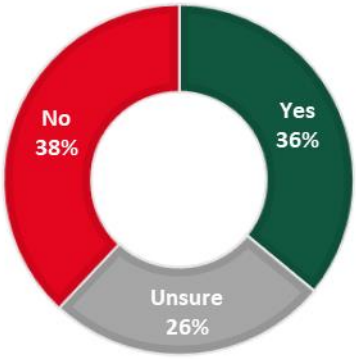
19. **How effective do you think the current method to demonstrate conformity and quality is?** (Very good, good, neutral, bad, very bad)



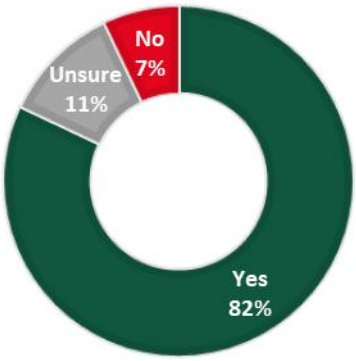
20. **Do you think it is feasible to use CodeMark for evaluating prefab/modular products or should a specific body be setup to perform the task for better efficiency?** (Yes – it is feasible to use CodeMark, No – a specific body should be developed, Neutral)



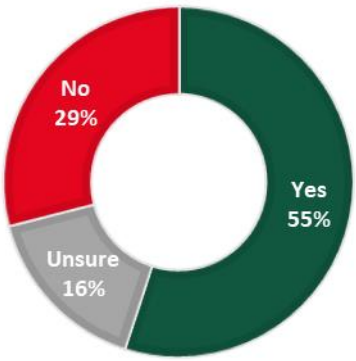
21. **Do you think compliance should be left to developing performance-based solutions?** (Yes, No, Neutral)



22. Do you think we need on-site validation as a means of certification as a fully assembled structure? (Yes, No, Neutral)

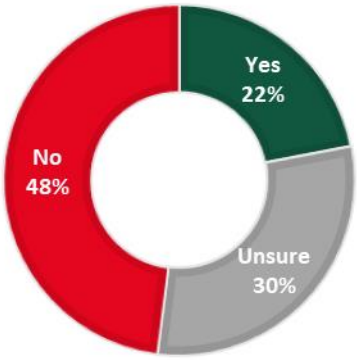


23. Would development of prototypes for testing and certification be a means to overcome certification and testing issues? (Yes, No, Neutral)

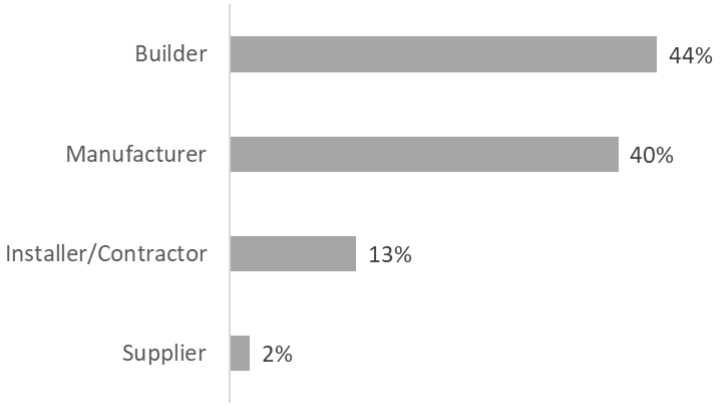


The following questions are in relation to chain of custody:

24. **Do you think the responsibilities and roles of stakeholders in the supply chain for prefab is clear?** (Yes, No, Neutral)



25. **Who do you think is responsible for ensuring the quality of the final product?**
    A mixed response was provided for this question. Notably, many stated that they expected the builder/head contractor or the manufacturer to be responsible for the final product, while others noted that the responsible party is dependent on the type of damage observed. Other responses were also provided, including:
    - All parties involved in the delivery from the manufacturer to the end-user.
    - All stakeholders associated with the building industry including government bodies.
    - Both the builder/installer and the factory.
    - Builder if same as manufacturer, otherwise manufacturer. The manufacturer needs to identify ways to sign off or certify components.
    - Whoever caused the defect must take responsibility.
    - Manufacturer, transporter, and installer.
    - Building surveyors and engineers
26. **Who do you think is responsible for defects** (Builder, Manufacturer, Supplier, Installer/Contractor)



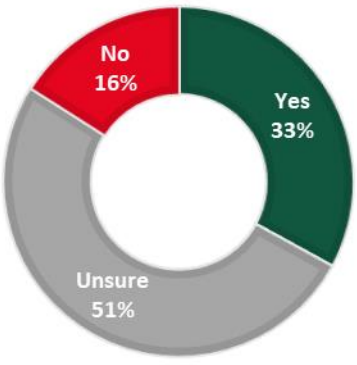
Final general questions:

27. **In terms of motivation, opportunity and capability, in your opinion what is the main factor that is holding us back?**

    The following responses were provided:

    - Government town planning rules (e.g., planning rules that limit multi tiny houses estates).
    - Finance and payment schedules.
    - Very expensive insurance.
    - High initial start-up or set-up cost for manufacturing facilities.
    - Costs associated with transportation.
    - Unclear regulation and compliance pathways.
    - Attitudes and understanding of the off-site industry, it is a method of building houses.
    - Builders not supporting innovation.
    - Architects not supporting of off-site construction because feel that they are not as involved or required for the design of buildings, as well as fewer variations allowed once the design is finalised.
    - Education within the industry. Fundamentally the requirements for buildings exist in existing legislation and regulation, and the onus is on the industry to comply. There seems to be motivation to bypass building requirements purely because it is hard to accommodate within the manufacturing process.
    - Difficulty in obtaining approvals due to non-experienced building surveyors/certifiers.
    - Road transport restrictions limit design options and make it harder to comply.
    - Builders' acknowledgment that they need to be accountable for the product that they deliver. It needs to be backed up by real insurance policies, that cover the consumer should the builder not deliver upon the quality. Each builder needs to have a star rating applied based on valid claims made by the consumer.
    - Scale, not necessarily enough demand for off-site constructed buildings.
    - Vested too heavily on Australian manufacturers.

28. **Do you think there are any other regulatory barriers that should be investigated?** (Yes, No, Neutral) If yes, please explain.



The following responses were provided:

- Approvers aren't up to speed with new technology.
- Contracts Act needs to be changed.
- Nobody regulates the builders now.
- Non-compliant products such as imported modular buildings that do not comply with our current Australian Standards.
- Progress payments.
- Government support.
- Transportation and logistics.
- Finance (security of payments), title & ownership.
- Sustainably including life cycle costing. Ability to achieve zero emissions buildings.
- Long term testing (at least 10 years) before a product is brought to market.
- Standard forms of construction contracts might be able to be modified to create a modular-specific contract, with emphasis on the design hold points.